CALIFORNIA STATE MINING BUREAU.

WM. IRELAN, JR., STATE MINERALOGIST.

BULLETIN No. 1.

A DESCRIPTION

OF THE

DESICCATED HUMAN REMAINS

IN THE

CALIFORNIA STATE MINING BUREAU.

By WINSLOW ANDERSON, M.D.

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INTRODUCTORY.

To the honorable Board of Trustees of the California State Mining Bureau:

GENTLEMEN: In compliance with your invitation, I have the honor to submit the following article on the mummified human remains now on exhibition in the Ethnological Department of your Bureau.

Subjoined to the description and measurements of these ancient bodies I have made a few observations on: The infancy of the intellectual races and their ethnological classification; some of the habits and foods of the savages now inhabiting different parts of the globe; the probable origin of the aborigines of the Pacific Coast, their historical traditions, burial ceremonies, myths, etc.—all relating more or less to the existence of a once flourishing race—the ancestors of our present mummifications.

In the preparation of the paper I have availed myself of the many interesting and valuable anthropological and ethnological data from the pens of some of the most renowned scientists and writers the world has ever produced, and it is desired to make due acknowledgment here to all those who have not been mentioned in the body of the article. Prominent among these are the names of Darwin, Huxley, Spencer, Haeckel, Cortes, Acosta, Clavigero, Duran, Sahagun, Diaz, Chaves, Karl, Snell, Hale, Flint, Farrar, Herrera, Bancroft, Prescott, De Bourbourg, Powell, and many daily, weekly, and monthly journals.

Acknowledgment is also due to Mr. W. S. Keyes for his valuable services in taking the photographs of the bodies from which the arto-type plates were secured.

It may be confidently predicted that when the Pacific slope—so rich in prehistoric remains—shall have been thoroughly explored, many interesting and valuable discoveries will be made relative to the origin of the Pacific Coast aborigines and their relationship to the European anthropophagous cave-dwellers.

I have the honor, gentlemen, to subscribe myself your obedient servant,

WINSLOW ANDERSON, M.D.

829 Broadway, San Francisco, May 1, 1888.

NATURALLY MUMMIFIED HUMAN BODIES EXHUMED IN THE SIERRA MADRE MOUNTAINS.

Through the liberality and untiring energy of Mr. J. Z. Davis, President of the Board of Trustees of the State Mining Bureau, a valuable collection of desiccated human remains has been added to the archæological department of this institution.

HISTORY OF THE DISCOVERY.

While the Mexican archæologist, Signor S. Marghieri, was exploring the eastern side of the Sierra Madre Mountains in Mexico, about two hundred miles south of Deming, between Coralitos and Casas Grandes, and at an elevation of nearly seven thousand feet, a hermetically sealed cave was discovered and explored. The floor was nearly smooth, the sides rough and rugged, and the vault covered with stalactites. The cave was of considerable dimensions, and proved to be a veritable sepulchre, for at the far end of this cavern, four mummified human remains were found. The caves which this people sanctified by the inhumation of their dead, are generally situated in the cliffs, on the banks of some large river, or high up some precipitous and almost inaccessible mountain. (See the writer's article in "Science," September 23, 1887.)

The bodies were found in a sitting posture, hands crossed on the breast and knees approaching the chin, with the head inclined forward. They were all carefully shrouded in their burial garments, and accurately

placed facing the rising sun—the source of all light—presumably ready to rise at a moment's warning, shake the dust from their heads, and walk out of their sarcophagus. The male and the female (see Figures 1 and 2) probably husband and wife, were seated side by side, the elder child, a boy (Figure 3), was placed to the right of the father, and the younger child, a little girl (Figure 4), to the left of the mother. In addition to the burial shrouds the little girl was enveloped in the skin of an animal, similar to the method used on the islands of Fuerteventura, the better to preserve its tender frame.

Entombed in their cave sepulchre could be found no trace of any implements, utensils, or personal effects. No hieroglyphics or pictographs to indicate their history or give a clew to their identity.

The floor of the cavern, and the remains, were covered with a fine, impalpable dust, probably the accumulation of ages. No footprints of man or beast had desecrated the sepulchre since the time of the interment. Only one sign remained to indicate the advent of man to these now barren and desolate regions (besides the ruins of cities and casas to be noticed elsewhere), and that was the sealing of the opening of the cave. This had been accomplished by means of sun-dried, adobe bricks, and adobe paste, or plaster, together with natural rocks from the mountain. So carefully are these caves sealed that none but an acute observer would notice its artificial closure.

Professor Marghieri and party having determined to convey the bodies to San Francisco, the utmost secrecy was necessary, for it would have been all their lives were worth to have the Indians discover the contents of

their parcels. The aborigines of this, and many other localities, entertain the greatest superstitious veneration for their departed ancestors, amounting, in many cases, to actual worship, believing the spirits of the dead, of whom they cherish fabulous accounts, hover over them and their dead bodies, and protect the community from evil. Should the bodies be removed, the spirits would also follow, and the Indians would lose their guardians and spiritual advisers. Indeed, some tribes believe that the spirit resides in the bones of the dead. Hence, whilst the Indians did not know specifically the place of interment of the mummified bodies, their legends teach them that the mountains and caves are peopled with the spirits of some great nation of whom they are pleased to call themselves descendants.

Accordingly, the bodies were carefully wrapped in such cloth as they had, and packed in sacks and strapped on the backs of the pack mules, and conveyed some two hundred miles to the nearest railroad station, where they were carefully repacked in suitable cases, and transported to San Francisco.

Having ascertained their whereabouts, Mr. J. Z. Davis lost no time in purchasing the bodies, and generously presented them to the State Mining Bureau, where they form one of the many notable attractions that are daily viewed by hundreds.

Aside from their great curiosity, as being among the first natural mummifications discovered on this coast, these well preserved human remains present a great many points of general and scientific interest.

DESCRIPTION OF THE BODIES.

These naturally mummified bodies differ from mummies proper, in the general acceptation of the term, inasmuch as no embalming process for their preservation was used. They were desiccated in their cave sepulchre by the natural elements. The dry hot atmosphere extracted all the moisture from the tissues, and the bodies literally dried up as we would dry jerk-beef, or as the Indians of to-day dry the bison (buffalo) meat which keeps for years.

There is no evidence of these bodies having undergone any preparatory process. The brain, heart, lungs, abdominal, and pelvic viscera are all intact and dried to a solid consistency.

Figure 1 (*a and b*) represents the powerful frame of a male body, about five feet eight inches tall and well proportioned. The bones are large, and he must have had an excellent physique. He probably weighed between one hundred and eighty and two hundred pounds. All the body now weighs is fourteen pounds!

The integument is well preserved, and presents the appearance of dried hide, or thick parchment, of a dark gray color, and all that remains between it and the bones are the dried muscles, tendons, nerves, and fascia. The body is well developed, the shoulders measuring from one acromion process to the other, three hundred and ninety millimetres (about fifteen and a half inches); the hands are small, and the fingers tapering; the feet are also small, measuring two hundred and forty millimetres (about nine and a half inches), and highly arched. The phalanges of the digits are perfect, each having the

Fig. 1 a.

Fig. 1 B.

normal number of bones, and the ungual appendages are well preserved and not unusually long.

The body has dried in the sitting posture, hands crossed and knees drawn towards the chin. It will be observed that the cheek and lips on the left side protrude. This probably occurred during the time of mummification; the moisture leaking from the interior of the brain and surrounding tissues, through the cribriform plate of the ethmoid at the anterior portion of the calvaria, through the cribriform foramina into the inferior meatus nasi, and the head being inclined toward the left, produced this bulging from the force of gravitation. Being itself in turn dried up, the mouth maintained its present shape. Short stiff hairs can be seen on the head. The eyebrows and eyelashes are also distinctly visible. A little hair can also be noticed on the upper lip, but very little beard anywhere on the face. The ears are closely pressed against the sides of the head and only the cartilages remain. The eyes are quite perfect, and present a slight outward obliquity. The nose, originally broad, has been more flattened by the shrinking of the cartilages and the alae nasi. The lips are stiff and solid and the tongue is shriveled to the consistency of cork. There is a full set of masticators in his mouth, thirty-two in number, and all quite well preserved. A few of the dentures only have the enamel worn down to the dentine. The ribs are large and well formed, indicative of a well shaped chest. The genitalia are well preserved.

It will be observed that on the head there has been a large growth of hair, on the face very little, and on the body scarcely any at all.

CRANIAL MEASUREMENTS.

(Figures 1, *a and b.*)

Owing to the dried integument and facia covering the cranium, accurate measurements of the skull are well nigh impossible. The following measurements, however, have been made with as much care and accuracy as the subject permitted. The cranial measurements are as follows:

Circumference, 530 millimetres; length occipito frontal, 178 mm.; breadth bi-bregmatic, 140 mm.; breadth of frontal, 108 mm.; height, 135 mm.; facial angle, 71°.

The sutures and wormian bones can not be inspected. The maler bones are quite prominent and the lower maxillary and face may be classified with the group, orthognathous.

A careful study of this mesocephalic head would indicate that its possessor was of more than average intelligence. The perceptives are well developed. And, although the animal passions undoubtedly predominate, there is enough veneration or religion to class it among the scaphocephalic skulls.

Figure 2 *(a and b)* represents all that is earthly of what was once a woman and a mother. She is in a better state of preservation than the preceding body. From a measurement of the individual bones, she would be about five feet five inches tall, and weighed, perhaps, about one hundred and fifty to one hundred and seventy pounds. The body weighs, in its present condition, only twelve pounds! The posture, integument, body,

Fig. 2 a.

Fig. 2 B.

etc., resemble the one previously described. A rare chance is here given for the examination of the internal organs (see Figure 2, *b*), owing to an absence of integument on the major portion of the right side. The lungs resemble a dried sponge in appearance, and the heart looks like a dried piece of meat. The great blood vessels, and the abdominal and pelvic viscera can be explored, and with the exception of being all shriveled up, there is no anomaly, either in position or arrangement. The large, oval pelvis, and the once well developed mammæ bear unmistakable evidence of gestation. The hands and feet are small and well shaped; the foot measuring only two hundred and fifteen millimetres (about eight and one half inches). On the head will be seen a luxuriant growth of hair, which centuries have not yet succeeded in destroying. It is very fine in texture, of a dark brown color, and entirely unlike any Indian hair seen to-day. A curious feature is observed in connection with the small, well proportioned ears, both of which are perfectly preserved, and that is, in each lobe is worn, even in the stillness of death, a piece of hollow bamboo or reed, about forty millimetres in length, and ten millimetres in diameter. This was likely considered an ornament in her day. Our Indians of to-day pierce the helix and anti-helix of the ear, through which holes they suspend ornaments of different kinds. The single perforation in the lobe of this mummified woman's ear would indicate a custom observed by her people, similar to the customs in vogue in the more civilized countries, and are not usually observed by Indians of our own period.

The windows of the soul, although now sightless and

dim, are singularly perfect, presenting a slightly outward and upward obliquity of the external canthi.

The nose is also quite perfect, and inclined to be rather broad and flat than thin and protruding. The maler bones are very prominent. The lips thin and stiff, and the tongue dried and solid. Two central incisores and one canine of the superior maxillary are gone, and several other teeth are badly caried.

CRANIAL MEASUREMENTS.

(Figures 2, *a and b.*)

Here, again, the same difficulty of hair and dried integument prevent absolutely accurate measurements. The skull measures: Circumference, 503 millimetres; length, occipito frontal, 166 mm.; breadth, bi-bregmatic, 128 mm.; breadth of frontal, 103 mm.; height, 132 mm.; facial angle, 69°.

This skull presents a large forehead and well developed reasoning powers. The woman was likely filled with noble instincts and motherly kindness. It is very rare to find so good a head among Indian women of to-day.

Figure 3 is the mummified remains of a little boy about seven years old. The little fellow had been enveloped in his burial shrouds the same as the larger bodies—hands crossed on the chest, knees doubled on the breast, and the head inclined forward. All the bodies were likely tied in this position when placed in the cave. The body is about three feet tall, and weighs now only three pounds! The same general characteristics as to skin, tissues, bones, etc., that were observed

Fig. 3.

Fig. 4.

in the preceding bodies, may also be seen here. The head is well developed for a boy of his age. The hair has been broken off near the scalp. Only the cartilagenous parts of the ears remain. There is the same contour of face—flat nose, high cheek bones, outward obliquity of the eyes, etc. The upper and lower incisores and canine of the temporary or milk teeth are gone, and the permanent set coming at their roots in the alveolar processes.

The two anterior molars of the superior maxillary are just appearing through the alveolar processes, establishing the age with tolerable accuracy at about seven years.

CRANIAL MEASUREMENTS.

In circumference the skull measures 440 millimeters; length, occipito frontal, 146 mm.; breadth, bi-bregmatic, 120 mm.; breadth of frontal, 60 mm.; height, 114 mm.; facial angle, 71°.

Considerable of his burial shrouds remains about the body yet. The major portion of it is cotton fabric, firmly secured around the body by a stronger cord, made of braided hair.

Figure 4 is all that is earthly of a little girl, about fourteen to eighteen months of age. She weighs only a pound and a half!

The little one has been enveloped in an animal's skin, the better to protect its tender frame. Both feet are gone, and the tibiæ and fibulæ protrude through the skin. The four upper and four lower incisores, with the corresponding canine teeth, have made their appearance, showing the child to be about fourteen to

eighteen months old. Otherwise the same features are noticeable in this as in the preceding figures.

It would appear that the group of four belong to one family, and that they were buried by friends, and hermetically sealed in this cave for fear of some real or imaginary foe. It may have been at the time of the Spanish invasion, or it may have been during the warlike times anterior to this date, when the Aztec confederation was warring with the Toltec people.

From their physical and mental developments the race seems to have been a superior one.

The facial features observed in these bodies are not those we find in that locality now. The cranial configurations and physical appearances would rather favor Aztec lineaments than those of our Indian of to-day. The fine dark brown hair is certainly not Indian, nor do the small hands and feet bear much resemblance to the huge hands and feet we see on the Indians now living. It is not desired to be understood that a race or classification can be even approximately established by the measurements of a few crania; for it can not. It only aids us in determining that particular individual's peculiarities. Too many ethnological classifications have been advanced on the measurements of a few skulls and on the descriptions of a few bodies. Measure, for example, a few skulls of any race, and see how much they differ in the very essentials of capacity, circumference, length, breadth, height, facial angle, etc., that go far in the classification of ethnologists. We may draw attention to the similarity existing between these bodies and the Asiatics, for instance, but we cannot *a priori* establish a relationship, nor can we posi-

tively determine from our present data that these bodies are Toltecs or Aztecs, however much our own views may favor such a theory.

BURIAL SHROUDS.

The fabrics found on the bodies, forming the burial shrouds, are chiefly composed of cotton, hair, hide, grasses, and the bark of willows. The cotton is twisted and coarsely woven, each thread being from a half to one millimetre in diameter. The hair is treated in like manner occasionally, although usually it is braided with three or four divisions in each cord. Frequently we find strong strands made of strips of hide covered with willow bark.

Although the weaving of this interesting people is that known as the "plain" process, that is, where the weft passes alternately under and over the threads of the warp, producing more or less open mesh cloth, yet considerable skill and ingenuity were observed in the manufacturing of their blankets, mats, and ornamental cloths, which were frequently interwoven with beads and colored threads, presenting various designs. Grasses and straws were also woven into mats and cloths, which were of great durability. The skins of animals were also used for clothing purposes.

OBSERVATIONS ON THE INFANCY OF THE INTELLECTUAL RACES.

The origin of the human family has ever been shrouded in the deepest of mysteries. Scholars of the first eminence have given to the world the results of their re-

searches, but, unfortunately, no two of them are agreed. We may accept any one of the three prominent hypotheses, each one of which has been so ably advocated, from the days of Camper and Blumenbach, down to our own time.

The first, or special creation theory, is that of the monogenists. It teaches that Adam and Eve were created in the alluvial valleys of Asia, and brings to its aid the records of holy writ. Many of the most renowned ethnologists and thinkers of the age support this hypothesis. Anatomically considered, there is no difference between a Caucasian and an Ethiopian, or a Caucasian and an Indian, except, perhaps, the contour of the skull and face, stature, etc. Bone for bone, however, they are anatomically alike. It is observed that climate, habits, etc., account largely for the difference in the color of the skin, texture of the hair, etc., and true it is, a vine grown in the dark is found to be translucent, and almost colorless. Likewise the bear is white in the Arctic region, brown in the temperate, and black at the equator, although anatomically allied.

Man, unlike animals, the monogenists claim, is a direct issue of the creative, or divine power, and that the Hebraic record is the only solution of the origin of things.

The polygenistic, or second theory of the creation of man, teaches us that there was not only *one*, but that there were *several* special creations—one for each race, and that climatic surroundings do not account for all the diversities and differences found in the human race. The learned ethnological authorities advocating the polygenistic theory, argue that the Mosaic account is

true, but that it only includes the history of one race. These authorities, although directly antagonistic in many of their views, must be received with due respect, owing to the distinguished positions they have earned in the many branches of anthropology.

During the last fifty or hundred years these two prominent theories have not materially changed.

The third hypothesis, that of evolution, is of more recent birth, and although it may be more repugnant to the *quasi* scientific mind, it is nevertheless truly scientific. We are all more or less familiar with the evolution of life as witnessed in the infusorial animalcula in water, spores in the air, generation of fungi in cereals, and birth, as it were, rising out of death. In a few hours a decayed cabbage head, or a putrescent piece of meat, under favorable conditions of temperature and moisture, will teem with new life. It is not desired to be understood that an extreme view of evolution is advocated, or even implied, for it is not believed possible to evolve, generate, or create organic life in the laboratory out of inorganic elements. The egg whose germinal vesicle has not been fertilized by the male bird cannot bring forth a chick, nor can inorganic atoms bring forth organic life.

Through countless ages, natural selection, the survival of the fittest, continual advancement, development, and improvement have at last evolved man in his present condition. The human species has reached its ultimatum of physical perfection. The *fixity* of *type* is stamped on the human embryo long before it is discoverable by man. Naturalists point out the anatomical similarity between man and beast. In his embryonic

state man cannot be differentiated from the wolf or the horse by the most powerful microscope or by the most delicate analysis. The germs of the embryos of the tortoise at the fourth week, the chick at the fourth day, the dog at the fourth week, and man at the fourth week, are alike insusceptible of differential demonstration. Physiologically and chemically they are identical. Indeed bold thinkers of the present day assert that man is not a biped, and that his natural mode of locomotion is on four instead of on two limbs. The *foramen magnum* would certainly indicate that the head was originally in a horizontal relation to the vertebræ, and the sacrum and coccyx bear a strong resemblance to the caudal extremity in animals.

ETHNOLOGICAL CLASSIFICATIONS.

On the next stepping-stone—ethnology, or the science which treats of the classification or races of man—we find monogenists, polygenists, and evolutionists, again trying to unite their forces in analyzing and classifying humanity.

Thus we find that Virey gives only two races of men on the globe. Cuvier makes three. Linnæus increases them to four. The great Blumenbach issues five, Buffon six, Peschel seven, and the renowned Agassiz eight different races. Pickering comes with eleven, and the learned Fredrich Müller assures us that there are twelve. Bory de St. Vincent sees fifteen. America's greatest anthropologist, Morton, increases the number to twenty-two, while Crawford has sixty and Burke sixty-three special creations. These classifiers represent the highest authority of which the world can boast, men who

have devoted their lives and powerful intellects to the intricate problem. Doubtless they would all agree had they adopted the same standard of comparison, but one distinguishes a race by geographical location; another by language, habits, and mental traits; another by stature, contour of skull and face; another proposes the color of the skin, and still another the texture of the hair; while the most acute observers combine all the distinctions and characteristics, and still they give us from *two* to *sixty different* human races.

Adopting whatever classification you may, and accepting whichever theory of creation you will, we can almost admit that there is not as much difference between the higher forms of apes and the lower forms of savages as there is known to exist between the highest and the lowest forms of humanity, when we look at the races existing to-day on nearly all parts of the globe. If the poor miserable savages are not actually below the brute creation, they are certainly not very far above it. Look at the Fuegian, for instance, crawling from the lair in which he lies, coiled up like an animal on the wet ground, to gather the food on which he subsists, mussels and berries, whenever hunger demands it. On state occasions they vary their bill of fare by killing and eating their old women. Their language is an inarticulate clacking. The negroes of New Guinea live on the trees, and spring from branch to branch, like monkeys, gesticulating, screaming, and laughing, and eke out their living on the indigenous fruits, as do the apes themselves. The Alforese of Ceram also live in trees, like the birds, each family being in perpetual hostility with every other family, human and animal.

The forest tribes of Malacca communicate by means of noises very similar to the native birds. Again, the Dyaks hunt and kill the wild people of Borneo as if they were monkeys. The cannibal Fans of equatorial Africa bury their corpses for several days before they eat them.

In Chinese cities rats are sold at fifty cents per dozen for the table. The hind quarters of the dog command a higher price than those of lamb or mutton. In Brazil ants are eaten alive with resinous and spicy sauces. In Africa they are stewed in grease. The East Indians catch the ant in pits and wash them in handfuls, and eat them. One of the most costly dishes in Siam is a curry made of ants' eggs. Shrimps are eaten alive by the Sandwich Islanders. The Singalese eat the bees after robbing them of their honey.

The negroes of the West Indies eat baked snakes and worms fried in fat. In the Pacific Islands lizards and their eggs are considered wholesome. Roasted spiders are used for dessert by the New Caledonians.

A pigmy race in South Abyssinia, the Dokos, grow their nails like the talons of the vulture to enable them to dig up ants and tear in pieces the flesh of serpents, both delicacies which they eat raw. Most any animal compares favorably with the fierce Bosjesman, whose diet is composed of worms, beetles, and pismires, unless he can share with the hyena the putrid carcass of a buffalo or an antelope. A gibberish speech, like the growling of a mad dog, is the language of the Yamparico, who lives on roots, crickets, and different species of bugs. The aborigines of Victoria live on roots, grubs, mushrooms, and frogs, with an occasional feast in the

shape of a new born baby, killed, roasted, and eaten by the parents and friends. The locust plague on the Pacific Coast in 1875, sent by the Great Spirit, was a source of worshipful thanksgiving to the Digger Indians, who dug large pits, swarmed them full of locusts, which they killed, dried, and ground to powder in their stone mortars, and thus laid in a store of food which lasted them for several years.

The Russians use the fermented liquid of cabbage for their beverage. It is called "quass," and may be described as resembling in taste a mixture of stale fish, washed in soapsuds; and next to beer, more civilized (?) people drink it, than any other beverage.

After they have wound the silk from the cocoon, the Chinese eat the chrysalis of the silkworm. In Mexico, parrots are eaten, and in the Argentine Republic, skunks are much sought after for the table. The African bushmen are very fond of spiders, and caterpillars are very dainty and costly.

The most ghastly ornamentation I have known is worn by the houseless, mischievous, and vindictive Andamer; it consists of a row of skulls, worn around the naked necks of this form of humanity. The Bannaks wear lumps of fat meat, artistically suspended from the cartilages of the nose.

It seems, indeed, hard for us to look back upon our ancestors, as a miserable anthropophagous population, maintaining an inglorious struggle with the powers of nature, wrestling with naked bodies against the forest animals, and frequently forced to dispute their cave dwellings with the hyena and the wolf, and yet we have but to look at the leather-skinned Hottentot, whose hair

grows in short tufts, with bare scalp between, and is only a creature of passions, feelings, and appetites.

Look at the wild people of Borneo, the Negrilloes, of Armanga; the Battas, of Sumatra; the hairy Ainos, of Jesso; the Hyglous, of the White Nile; the Aborigines, of India; and even the Cagots, and other mandities of France and Spain. These species, and we must call them human, with squalid habits, ugly and deformed heads, hideous aspect, and prognathous faces, have probably lived as long, and perhaps longer, than the Caucasians; and, as Darwin observes, they are supposed to enjoy a sufficient share of happiness and comfort (of whatever kind it may be) to render life worth having.

Many races on different parts of the globe attribute their origin, not to the gods or demigods, not even to lions, as do the Sahos, or to goats, as do the Dagalis, not to the sun or moon, as do many of the Pacific Coast tribes, but to *apes*. This has been the cherished belief for ages among the Miantsee or aborigines of China, a country whose boasts of creation antedates ours by many thousands of years. The Thibetans and many African tribes also lay claim to the ape as a forefather.

Whilst not advocating evolution *per se*, we are almost forced to admit its possibility on purely scientific grounds, even to the extent of evolving man through the countless ages of the earth's existence, out of—not inorganic atoms or molecules, but out of flesh and blood, by the aid of the All-wise Creative power. As Professor Le Conte says: "I believe that the spirit of man was developed out of the *anima* or conscious spirit of animals, and that this, again, was developed out of lowest forms

of life-force, and this in turn out of the chemical and physical forces of nature; and that at certain stages in this gradual development, viz., with man, it acquired the property of immortality precisely as it now, in the individual history of each man at a certain stage, acquires the capacity of abstract thought."

The following striking example shows what can be done in *one* generation in the way of transforming a land animal into one capable of living entirely in water. By taking the embryo of the land salamander out of its egg and keeping it in water at a moderate temperature, abundantly supplied with oxygen, and amply fed with small living water animals, its organism will change. The embryo inhales the oxygen held between the molecules of water, and not the atmosphere, like its parents, breathing with lungs. The embryonic lungs therefore remain undeveloped, but, by way of compensation, small gills will appear on each side of its head. This function of breathing by the gills will gradually increase as the body grows. Feeling the necessity to swim and not to creep as do its land parents, the four extremities become mere rudimentary appendages, while, on the other hand, a vigorous rudder tail develops. The new function of swimming calls forth fins, and the animal actually develops new organs which the parents did not possess. This is a simple experiment which can be accomplished by any one with a little trouble. Thus we find substantially a new animal is produced which elsewhere does not exist. This proves that new organs and new functions are developed when necessary to the individual's existence; in other words, evolution, pure and simple.

There is nothing incompatible or inconsistent in such a view with the Mosaic records; and I am proud to say that the days of theological narrow-mindedness and denunciation of scientific truths are happily disappearing, and seeking as true an investigating channel as does the snow on the mountain side under the influence of the sun's rays seek the proper channel for its sparkling waters.

The three great Bishops of the Church of England (1887) are the pioneers in this noble line of inquiry—development (evolution). An extract from one will suffice: "* * * And to what are we indebted for that potent word, which, as the wand of a magician, has at the same moment so completely transformed our knowledge, and dispelled our difficulties? To modern science, resolutely pursuing its search for truth, in spite of popular obloquy, and—alas! that one should have to say it—in spite, too, often of theological denunciation." [*Bishop of Manchester.*

SOME OBSERVATIONS ON THE ORIGIN OF THE ABORIGINES OF THE PACIFIC COAST.

The origin of our Western Indians, like that of all the other American aborigines, is shrouded in as much darkness and as many uncertainties as the origin of the human family itself. Nearly every nation, and almost every country, has claimed for itself ancestral relationship to our American Indian. Authorities advance the opinion that the red man is a descendant of the ten lost tribes of Israel. Others, that the Indians are Phœnician merchants. Scandinavia, Iceland, and Greenland lay very strong claim to them. Japanese junks are said to have wafted across the ocean and struck on these western shores and peopled America. Carthaginians are said to have shipwrecked on the eastern coast. The Polynesian Islands, Australia, Africa, and Asia alike receive their quota; but before we accept any of the traditions, or even the most popular of these, viz.: that one or two races, springing from the banks of the river Oxus, in the alluvial valleys of Asia, wandered here and there by land and by sea, and thus peopled the whole world, let us listen to the aborigines of America themselves, who furnish us with many interesting and remarkable accounts of their own origin, which, in some respects, simulate that of the civilized races. Take, for example, the Maya or Quiché empire, which was in a high state of civilization at the time of the Christian era. Extensive and complicated political and religious

observances were in vogue, massive temples were reared, and the priests and kings had full sway.

The Quiché nation is, perhaps, richest in mythology. Their version of creation is as follows:

The Great Spirit, having, by one word, created this globe out of the clouds, having created all the flora and fauna, and made this earth like heaven itself, and, being justly proud of His work, He commanded the creatures to send forth praise and thanksgiving for their existence. But, no; the dumb brutes failed to obey the mandate. The Great Spirit, becoming angry at such ingratitude, cursed the animals, relegating them to have their flesh torn from their bones, and be killed and eaten. (Hence the origin of eating animal flesh.) Having satisfied his wrath, the cloud God called a council, and it was arranged to make man, that he might sing praises to his Creator. Accordingly, man was made of clay, and much was expected of him. When, however, it was time for praise service, the clay man was found to be without volition or speech. This greatly enraged the cloud gods, and the poor clay man was ordered to be instantly killed. He was, accordingly, drowned forthwith.

After long and careful deliberation, another man was made. This time of wood, as the clay was considered too heavy. A woman was also made to keep him company. Although the man was wooden, his companion was made of pitch—a good combination. Every thing went well for awhile, and the moon, who now took a hand in creation, peopled the whole world with wooden manikins. Intelligence seems to have been at a low ebb, for our wooden kingdom soon forgot to sing praises to the clouds, whereupon the Heart of Heaven became

very much angered, and rained *thick, hot resin night and day* on the poor wooden men and women, and killed them all, excepting a very few penitent ones. These surviving few may be seen to this day, living in the forest in happiness, never forgetting to sing praises to their cloud Gods. These wooden people are known to this day as apes or monkeys. After these several trials the Great Spirit was discouraged, and creation was given up for awhile. Nevertheless, at length His wrath subsided, and the other gods prevailed upon Him to try once more his creative power. This time man was to be made as nearly perfect as the gods themselves. The Great Master accordingly made four men and four women out of yellow and white maize, which grew abundantly on the earth in the meantime. These new corn people gave general satisfaction, and their Creator has permitted them to people the world.

The Aztecs were created in an entirely different manner. Their account of creation is in this wise: The God and Goddess in the sky were blessed with a male offspring in the shape of a flint knife. Having several other children in their heavenly abode, it was feared that this hard-hearted flint son would do mischief, and to secure the serenity of heaven His Flint Majesty was cast out of the clouds forever. In his aerial flight, the Flint Son of God fell into the seven caves on this earth and dashed into six thousand and six hundred pieces. Immediately there sprang up six thousand and six hundred demigods from the pieces of the Flint Son. That they might have servants and companions as became their rank, the mother Goddess was implored. She directed them to make application

to Hades for a bone and when obtained to sprinkle it with their own blood. One of the most valiant was forthwith sent to the Infernal region to crave a bone from his Satanic Highness. It appears that this domain was already well supplied with bones, and tradition has it that prior to this present creation the earth was peopled with giants, but the cloud Gods sent them all to the lower regions, hence the supply of bones there. The bone was obtained by the messenger, but owing to some slight misunderstanding with the keeper of Hades a hasty retreat was deemed expedient, and a fall caused the bone to break, so that when earth was again reached only a handful of bone was left. The few pieces, however, were carefully sprinkled with blood and in a few days a pretty little maiden sprang up from each little splinter. Thus do the Aztecs boast of their genealogy from both God and the Devil.

According to the Tezcucan annals the sun sent a dart—one of its beams—through the earth in Mexico, thereby producing a large hole, out of which man sprung, full grown.

The Hyperboreans attribute their origin to our common canine. The Neeshenam were created by the moon.

Plants and animals are worshiped as creators. Old Sol comes in for his share of the praise of creation among several of the aborigines.

The tribes of Lower California believe that their souls retreat to some of the verdant isles of the sea, there to await the birth of some infant, whose body is occupied by the departed spirit.

Many of these creative myths resemble those of the

old world, especially the Asiatic, which may point to Asia, as Mr. Powers remarks, as the probable origin of some of our aborigines.

From the language, our American aborigines may be of common origin, either indigenous or foreign, or they may be from widely different sources and races, as we have on the Pacific Coast alone over six hundred different tongues.

Language has latterly gained much ground as a crucial test in the determination of the origin of races. Taken conjointly with craniology, facial angles, stature, color of skin, microscopical structure of the hair, and geographical distribution, it certainly must add materially to these data. Taken singly, care must be exercised, or the errors will be as glaring as those frequently committed by craniologists when they pronounce crania as belonging to this or that race, by merely examining half a dozen skulls.

Probably the most reasonable view to take of the origin of the aborigines is this: That different parts of the Western Hemisphere were peopled by different races or nations, or if we accept the polygenistic theory of creation, why the Indian was created contemporaneously with Adam and Eve. Evolution can help us out still more, for the same process that was going on in the old world may also have gone on in the new, the geological advantages remaining on American soil.

People the new world as you please, subdivide the aborigines according to any ethnological data you will, and I believe it will appear quite within speculative bounds to consider Anáhuacs or Toltecs and Aztecs of Asiatic origin.

Their fragmentary history, and pictorial writings would indicate that they came from the far northwest. If the Toltec and Mayo-Quiché empires flourished and rivaled in splendor and culture, in the magnificence of their temples and palaces, and in their complicated systems of religion and politics, those of the old world at the beginning of the Christian era, as it is claimed they did, then all must admit that it would have taken thousands of years to perfect or evolve such systematic governments.

Several similar characteristics can be traced to the Aztecs and the Asiatics, and indeed the Malays and Egyptians. Similar cranial contours and measurements. The hair on the head and the universal absence of beards and the scanty supply of hair on other parts of the body. Small hands and feet. The basic axis of the skull is short, flattened occiput and scaphocephalous crania. Prominent cheek bones. Outward and upward obliquity of eyes. The nose is rather broad than prominent,—color of the skin, and stature generally.

It is certainly within speculative bounds to consider the Eskimos or Innuits, Chukchees (Tsau-chu) and Chukluk-Mut inhabiting Eastern Siberia; the Okee-og-Mut, inhabiting the islands of Behrings Straits; the Aleuts-Aziag-Muts, etc., Kaviag-Mut; the Tinneh-Koyu-Kukhotana, Tenan-Kut-Chien, etc., and the Tlinkets-Chilk-aht-Kwan, Sitka-Kwan, etc., inhabiting American soil, of common stock, modified in the course of centuries by their pursuits, mode of living, environments, etc.

It would, also, be quite natural for these people to

migrate southward to a warmer climate and more productive soil, and thus extend along the coast to Mexico and Central America. This southward migration of northern tribes does take place. The scientific world is pretty well agreed that man has inhabited this globe at least one hundred thousand years in his present form. As many geological and morphological, as well as topographical changes have occurred within the known period of four thousand years, may it not also be possible that America and Asia were united by land at some time during this vast period?

It has been suggested to my mind that the Pacific Islands, Hawaii, Friendly, etc., bear evidence of this union at a period when the American continent was but a few islands in a vast ocean. In that event intercommunication was not impossible, nor would it be were the Pacific twice as broad as it is now.

We can also trace some similarity between certain religious rites. I will mention but one or two. Many of the American aborigines bury their dead and supply the graves with food and drink for months and years. The wily Chinese spread a sumptuous repast when a notable dies and place large sums of money near the dead to pay his way with in the next world; of recent date, however, the living eat the food and spiritualize the money in the shape of counterfeit to swindle the devil. This can be seen at any time at a Chinese funeral. The counterfeit money is thrown along the road that the devil may stop to pick it up and so allow the Celestial to be buried in peace.

HISTORICAL SKETCH OF THE PACIFIC COAST ABORIGINES.

In the sixth century we find the Anáhuac nation enjoying a high state of civilization. Their traditions and pictorals tell us they came from the far north. The pictorals, yet extant, are printed on long strips of cotton and prepared skins with bright red paint. They also carved on wood and stone. They built palaces, temples, and large cities.

In the eleventh century the Chichimecs and Aztecs, also coming from the far north, drove out the Toltecs (who went farther south) and occupied the vanquished country. The Aztecs from "Aztlan," the name of their ancient abode, or "Iztac," meaning white, soon gained supremacy, and although the Toltecs occupied a larger extent of country and attained a far higher degree of civilization, the Aztecs left us the best American language and the most complete history.

Large pyramids were erected at Cholula and Teotihuacan, probably near the Christian era, certainly prior to the sixth century.

Tenochtitlan, or Mexico, was founded early in the fourteenth century by the Aztecs. Traditionally, all the Aztec confederation, or Mexican races, came from the far northwest, and it is computed by the best authorities we have, that prior to the Christian era, as high a state of civilization existed in Mexico and Central America as could be found on any other part of the globe.

At the Spanish invasion the Aztecs occupied large

cities, with magnificent temples and palaces, parks and gardens, and enjoyed a superior system of politics, and advanced religious views for the age.

The splendor of Montezuma's empire rivaled the orientals. His palaces were decorated with solid gold and silver, and inlaid with precious stones. His family and household numbered several thousands, among whom may be mentioned one thousand wives, and almost as large a number of concubines. The customs and ceremonies of this powerful people are very unique and interesting, but want of space precludes more than a brief outline of some of their ceremonies attending the death and funeral rites.

When an Aztec of note was taken ill, the medicine man, relatives, and family were sent for, and solemn council was held. The simpler remedies of indigenous herbs, etc., were given. If these failed and a fatal issue was threatening, perhaps the "sweat house" would be prescribed. If the patient was not cured and still survived the treatment, the medicine man would sit for hours and bark like a dog at the poor patient.

If this failed, dust or water was thrown on the face, and lastly, incantations were used to drive out the devil. Generally, however, the patient died during the process of the treatment.

In the meantime active preparations were making for the funeral. The ceremony varied according to the mode of burial.

If cremation be practiced the body would lie in state for several days. The relatives and slaves of the household would neither eat nor drink for two days, at the end of which time, the general funeral feast was pre-

paring, and eating and drinking *ad libitum* was indulged in. Then all follow the remains to the funeral pyre in the temple. Many of the slaves and several of the relatives and frequently the favorite wives were slain, to go with their lord and master, that he may not want for comfort and may not be alone in the spirit land. It was considered an honor to die with a noble, for then, it was believed, that all would go to the highest heaven together.

The funeral pile is burning, music is playing to keep away evil spirits, the people moan and cry, and the victims shriek and struggle as they are forcibly led up to the altar, and thrown on their backs by four strong priests. A knife is now plunged into the poor victim's breast, and the heart is torn out, yet bleeding, and beating with the life that is scarcely extinct!

Immediately the heart is thrown on the funeral pyre of the deceased noble, and the victim's body is either consumed on a separate pile or taken home and eaten by the surviving relatives and friends. This sacred rite continues until the dead noble has enough wives and slaves with him to attend to his comforts in heaven (?). Several dozen people have been known to follow their chief to the next world in the manner above described. On other occasions the dead are buried in caves, and also in graves with their wives and effects.

The following remarkable burial custom obtains with the Mosquitos: The dead body is wrapped in fine cloth, and placed in a wooden coffin in his own house. Music is played to lull him to peaceful rest. In the meantime women inflict on themselves all kinds of torture, tear their hair out, cut their arms and faces, beat

their heads against the ground, and cry and shriek until they are exhausted. The men dance and yell, and drink "pulque" or "teuvetli" until they are drunk. This continues for several days. All at once four naked men, with their bodies painted so that the devil cannot recognize them, rush into the dead man's house, seize the coffin, and drag it to the place of interment. The music and mourners follow. The body is placed in the cave or grave, and a tent is erected over it, which is daily provided with food and drink for one year. Should the birds eat the food, and the drink leak through the porous vessels, then they are happy, for the dead man's spirit has eaten and drunk all he wants. The widow, at the end of the year, has the bones of her deceased lord dug up and placed in bed with her. For one whole year she sleeps every night with the dead man's bones. Having suffered penance for two years she has the bones permanently placed at the entrance to her house, or over the door.

Another custom, almost as unique, is observed by a Central American tribe. The body is placed in a deep pit, large enough to seat all the wives, and such of the relatives as must die with the deceased. Around the dead body, in solemn silence, sit the living, while the friends are fasting, feasting, and dancing on top of the ground. This continues for two days, when, at the proper time, dozens of strong men surround the pit and proceed to fill it up—the living being buried alive with the dead. Trees are planted around the last resting place of the family. If a mother die in child-bed, and the child be living, the infant is buried alive on its mother's breast, to enable it to obtain food in the next world.

In India to-day, in this nineteenth century, the wife is buried alive with her deceased husband, and the new born children are cast into the rivers for the fish to eat.

The kings and nobles of the early races of the Pacific Coast were frequently cremated, as this gave the succeeding king or noble an opportunity of satisfying the thirst for blood, and also to get rid of any obnoxious individual who was in the way. The ashes were placed in urns made of silver and gold. This was deposited in the temple or palace, at the feet of their patron saint, and a statue of the dead placed over it. In Central America, the head of the deceased was cut off and boiled. The skull was then afterwards fitted up to resemble the individual in life, and used for the head of his statue.

Embalming was also practiced by some of the aborigines. Their process was the following: The dead body was suspended over a slow fire of herbs and green boughs. Here it would dry and smoke for many days, until all the moisture was abstracted, and only dry skin and bones remained. In this condition many mummified bodies were preserved in the temples, where they were suspended on the walls for centuries.

Embalming, although of ancient origin, was never practiced extensively in any country. In the islands of Fuerteventura it was used, but the process is now lost. The preserved body was surrounded with aromatic branches and tanned skins of the hog or goat, and placed in caves. The Peruvians of Incas, the Gouanches, and the Egyptians, at the time of the Pharaohs, were the only people who practiced mummification to any extent. The art is entirely lost. I examined several Egyptian

mummies, some of which were four thousand years old. The skulls had been bared to inspect the bones of the face. In these the embalming process seems to have been the following: The bodies were wrapped in cloths and then covered with a layer of pitch or tar, again a layer of cloth and another covering of pitch, and this continued until a thickness of one half to two inches was obtained. The whole body was covered—perfectly hermetically sealed from head to foot, and as indestructible and impervious as time itself. The bones looked as fresh as though death occurred recently. The modern device of electro-plating dead bodies cannot be more lasting than the Egyptian embalming of four thousand or five thousand years ago.

Relative to the future state, the beliefs of the American aborigines very closely resemble the myths of older countries, particularly those of the Orientals. For example, the Apaches believe the wicked people to inhabit rattlesnakes after death.

Sparks from a volcano are supposed to be villains sent forth to torture the people.

"Will-o'-the-wisp" is a witch hunting for spirits.

The greatest superstition is attached to dreams by all the aborigines. It is believed that while a person sleeps some evil spirit takes possession of the body and actually accomplishes what the individual dreams.

A shadow is supposed to be the individual's other self.

When portraits and photographs were first taken of the tribes inhabiting the Gila Valley, the artists narrowly escaped with their lives, as it was believed that the "impression," or portrait, was the spirit transferred

by some magic power to the possessor of the photograph or picture.

As we have seen, the Aztecs were formed out of pieces of bone from the lower regions, so do they believe that wherever their bones are there also must be the spirit.

The souls of Sonoras dwell in caves.

The Tlascaltecs believe with the Hindoos that the souls of the dead return to earth and enter animals. The good souls enter clouds, precious gems, and birds of beautiful plumage; but the common and wicked souls pass into the inferior animals. Reincarnation was also believed in by several tribes. The Aztec souls are permitted to return to earth once a year to feast with their friends.

Note the similarity of our accepted myths of the old world.

The resurrection of the Egyptian Osiris, Orpheus, and Eurydice. Mithraic mysteries of Persia. The resurrection of the lifeless Sita in India. The Eleusinian mysteries permits the return of Kore to Demeter for one half of every year.

The metamorphoses in Celtic and Druidic mysteries in Gaul and Britain.

The Aztec confederacy, or ancient Mexicans, and before them the Iroquois and Toltecs, non-nomadic or towns-people, occupied northern Mexico, New Mexico, and Arizona, now represented by the Pueblos, Pimas, Moquis, Maricopas, and Pápagos. The prehistoric and early races, whose civilization and architectural progress have been the marvel of the world, building as they did large cities, houses, temples, and palaces of

great splendor,* and aqueducts for the supply of water and irrigating purposes. They cultivated gardens and fields which supplied them with food to eat and clothes to wear. Their burial places were frequently within their own houses; also in caves, mounds, shafts, natural and artificial sarcophagi situated on their own premises or in adjoining caverns or cliffs.

The temple-pyramid in Mexico is a superstructure of royal graves. The remains were placed in a sarcophagus, one on top of the other, until the pyramid reaches nearly one hundred feet in height, by several hundred feet at its base.

The ruins are justly called the "American Pompeii," and continue to attract merited attention from the scientific world. At the present writing, Professor Frank Cushing has charge of an exploring expedition in Arizona, under the direction of the Smithsonian Institute. Report reaches us that the ruins of a large city, "Los Muertos," he calls it, has been discovered and explored. This is situated on Salt River, near the junction of the Gila. As early as 1697, Father Keno made explorations in this same district, when he was establishing Jesuit Missions. He speaks of discovering extensive ruins, and a considerable population. Prior to this, the Spanish General, Coronado, in writing to the King of Spain, speaks of the ruins and of the people. Professor Cushing has discovered two thousand skeletons and mummified human remains; besides valuable prehistoric pottery, idols, utensils, and armaments of war and the chase, and for domestic purposes, etc., are exhumed.

* Using flakes of selenite for windows, and far ahead of Europeans at a similar period of civilization.

This will enrich the Smithsonian Institute, and the Bureau of Ethnology and Anthropology.

It is a source of regret that California does not take more interest in her prehistoric dwellers, and gather collections that would be invaluable to the scientific world. These could be collected at little expense, as many of them are at our very doors.

It is estimated that Los Muertos had a population of twenty-five thousand people, and that the "Seven Cities" along the Gila Valley represent the ruins of a population of more than two hundred thousand souls.

Wheat, barley, and corn, fabric, etc., indicate the high degree of civilization that these people enjoyed.

It is the opinion that some great calamity befell these people, like that of the inhabitants of Herculaneum and Pompeii, otherwise our ancient cities would probably be inhabited to-day. Earthquakes and volcanic eruptions have killed many of these people, and freighted more away, besides laying their flourishing cities in ruins. Several human bodies are found beneath walls as the excavation continues. The walls and temples are not mouldering away, but broken up and laid low on the ground. The people, except a mere remnant, have probably gone south, built the palaces and temples of the Mayas of Yucatan, and, indeed, the halls of the Incas of Peru.

The present bodies are certainly several hundred years old, and in all probability belong to the Aztec race.

One thing is certain, says *La Voce del Popolo*, that these remains belong to a race entirely different from the Indians who now inhabit the region where the

mummies were found. The sealing of the cave, and the absence of the usual implements and utensils, may indicate that they were buried at the time of the conquest. The exact date of burial must, for the present, at least, remain a mystery.

From our best geological and archæological data the American aborigines are supposed to antedate our anthropophagous ancestors, from the wilds of Asia, by many thousands of years.

CALIFORNIA STATE MINING BUREAU.

J. J. CRAWFORD, State Mineralogist.

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METHODS

OF

MINE TIMBERING.

By W. H. STORMS,
Assistant in the Field.

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PREFACE.

There is no attempt in this Bulletin to present a complete treatise on methods of mine timbering, but simply to give consideration to those systems ordinarily used in, or adapted to, the gold mines of California. Both in the lode and ~~deep~~ drift gravel mines of this State, those systems in use have been selected from the best practice and applied in various ways according to circumstances. In collecting the material herewith presented, many mines have been visited and the details of timbering work noted, so that those who have not an opportunity of comparing methods for themselves may be enabled to learn the practice of others.

It has been thought proper also to give some detailed account of systems of mine timbering used in other States where extensive ore-bodies are worked, since these are adapted to use here under corresponding conditions.

W. H. STORMS,
Assistant in the Field, State Mining Bureau.

METHODS OF MINE TIMBERING.

By W. H. Storms, Assistant in the Field.

The excavation of any considerable amount of earth, or rock, beneath the surface of the ground usually necessitates that the roof, and not infrequently the sides, of such excavation be sustained artificially to prevent caving. In these later years the size of underground excavations is so great, as compared with those formerly made, that the ingenuity and skill of the miner is taxed to the utmost limit. So successful, however, have miners become in devising novel methods to meet daily exigencies that the obstacles usually encountered in mining, among which are flakey rock roofs; soft, running ground; floods of water, sometimes scalding hot; and, worst of all, swelling ground with heavy pressure from all sides, including the bottom, have mostly been successfully overcome.

Before Deidesheimer's "square set" system came into use, the ingenious placing of posts, caps, and "stulls" constituted the only method of timbering, the multitude of conditions met in the mines making the combinations almost endless. Where veins occur in firm, solid rock, being perpendicular, or near it, the danger of caving is greatly lessened, and the amount of timber required is reduced to a minimum, but these conditions are exceptional.

Veins dip at all angles between perpendicular and horizontal, and vary greatly in width. Moreover, the character of the wall rocks, as well as of the ore itself, is so variable that unexpected problems are encountered daily. The shape of large bodies of ore is a matter of great importance in determining the system of timbering to be employed.

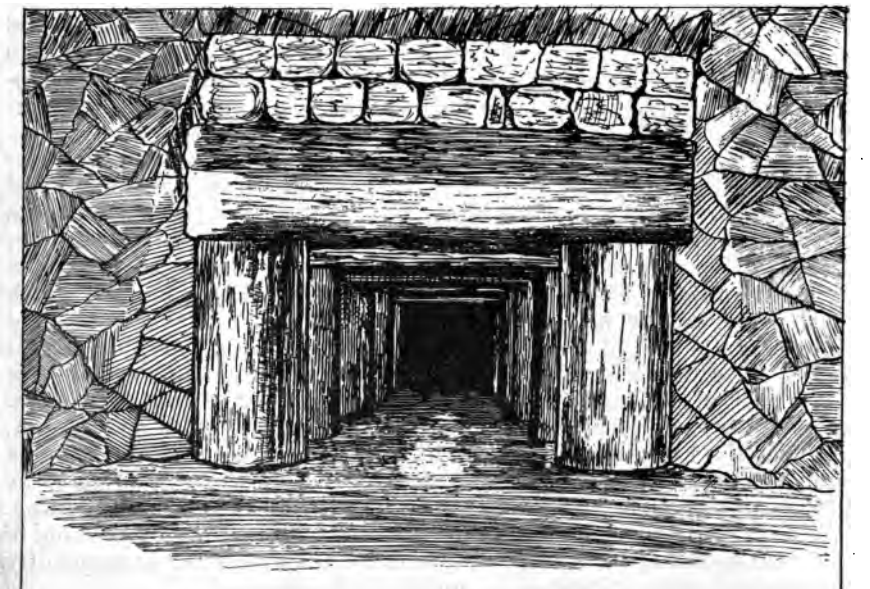
Through all this variety and change in form, dip, size, and character of the vein, or deposit, and in the inclosing walls, certain established principles are followed in sustaining the roof and sides, the constant aim being to prevent caving, and to avoid such a catastrophe timbers are placed with a view of holding the rock masses in place, and always in such a manner as to receive the strain directly. Those timbers which reach from wall to wall of an inclined vein (stulls) are not set at a right angle to the pitch of the hanging wall, but at a somewhat higher angle. The reason is obvious, for, if placed at a right angle, should a subsidence of the wall occur, the timber, partaking of this movement, at its upper end, would then have a tendency to fall of its own weight, whereas, if set originally above an angle of 90 degrees with the hanging wall, the subsidence of that wall only serves to wedge and hold the timber support more firmly, when it must bend and break before falling. When properly placed, stull timbers usually give sufficient warning of their weakness to permit of placing additional timbers and subsequently the removal and replacement of old or weak timbers.

To make an understanding of the various practices more comprehensive a number of drawings have been introduced in this article. As a matter of course certain exigencies are likely to arise, the character

which has not been anticipated, but in all cases the principles applied remain the same, and it is thought that the conditions most likely to occur have been treated fully enough to meet the demands of metalliferous mining generally.

KINDS OF TIMBER USED.

In some instances solid masonry is built to sustain certain portions of mines, and in late years iron has been introduced as a substitute for timber, but in American mines timber is most commonly employed. Ordinarily the location of the mine determines the kind of timber. Pine of various kinds is more extensively used than any other. Sugar pine and spruce are preferred when obtainable, but yellow pine is by far the most common. Oak is gladly taken when good sticks of sufficient size can be found. There are oak timbers in mines in Mariposa County, apparently sound, that have been in place for twenty years. They certainly outlast any other timber. Cottonwood and redwood are sometimes used when no other is obtainable, but are not at all desirable. In the desert in this State, in parts of Arizona and Nevada, miners take any timber they can get, even resorting to the yucca, which answers quite well for a time in that dry climate, when the pressure is not too great. At Silver Reef, in San Bernardino County, green yuccas were used in timbering a drift. They still stand in fair condition, having been in place five years. The Superintendent of the Gover Mine, Amador County, California, has commenced some experiments with spruce and sugar pine, placing them side by side in the same set in the lower levels of his mine, to test their durability.



ENTRANCE TO AN OLD MINE IN HONDURAS

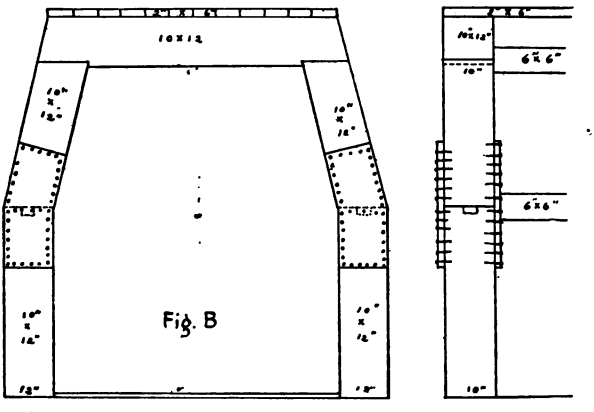
Fig. A.

TUNNELS AND DRIFTS.

The methods employed to sustain the roof and sides of tunnels and drifts are numerous, the existing conditions determining the method. Often the rock is sufficiently firm to stand without timber, but at times the conditions are annoying and dangerous.

Where the pressure is entirely overhead an upright post is set on either side of the tunnel, usually spread somewhat at the bottom, but otherwise always at right angles to the roof. (Drifts are frequently run on an incline, particularly in blanket veins, and also in fissures having a low angle of dip.) (See Figs. 2 and 4.) On these posts are placed a cross-piece called a cap.

When it may occur that the floor of a tunnel, drift, or cross-cut does not afford a firm foundation for the posts, as in soft, wet fissures, when not in ore, or as is often the case at the entrance to a mine, a cross-piece



ENTRANCE TO TUNNEL, CALAVERAS CONSOLIDATED MINE.
CARSON HILL, CALAVERAS CO. CAL.

or sill is first laid and the posts set upon it. A second cross-piece (the cap) is then inserted at the top, the ends resting upon the posts, the cap being employed in all cases whether the sill is necessary or not.

In working ground that is fairly firm, particularly in the drift gravel mines of California, a system of posts and "breasting caps" is used. This consists of a piece of timber, hewn or split, 2½ feet long, 1 foot wide, and 3 or 4 inches in thickness (the cap), which is placed against the roof, and a post of the necessary length is set beneath it, being driven into a perpendicular position by blows of a heavy hammer or maul. It is a cheap and secure method of timbering small drifts, and is often employed in large ones, the breast extending entirely across the channel. Lagging placed at right angles to the cap may be driven in above it when necessary.

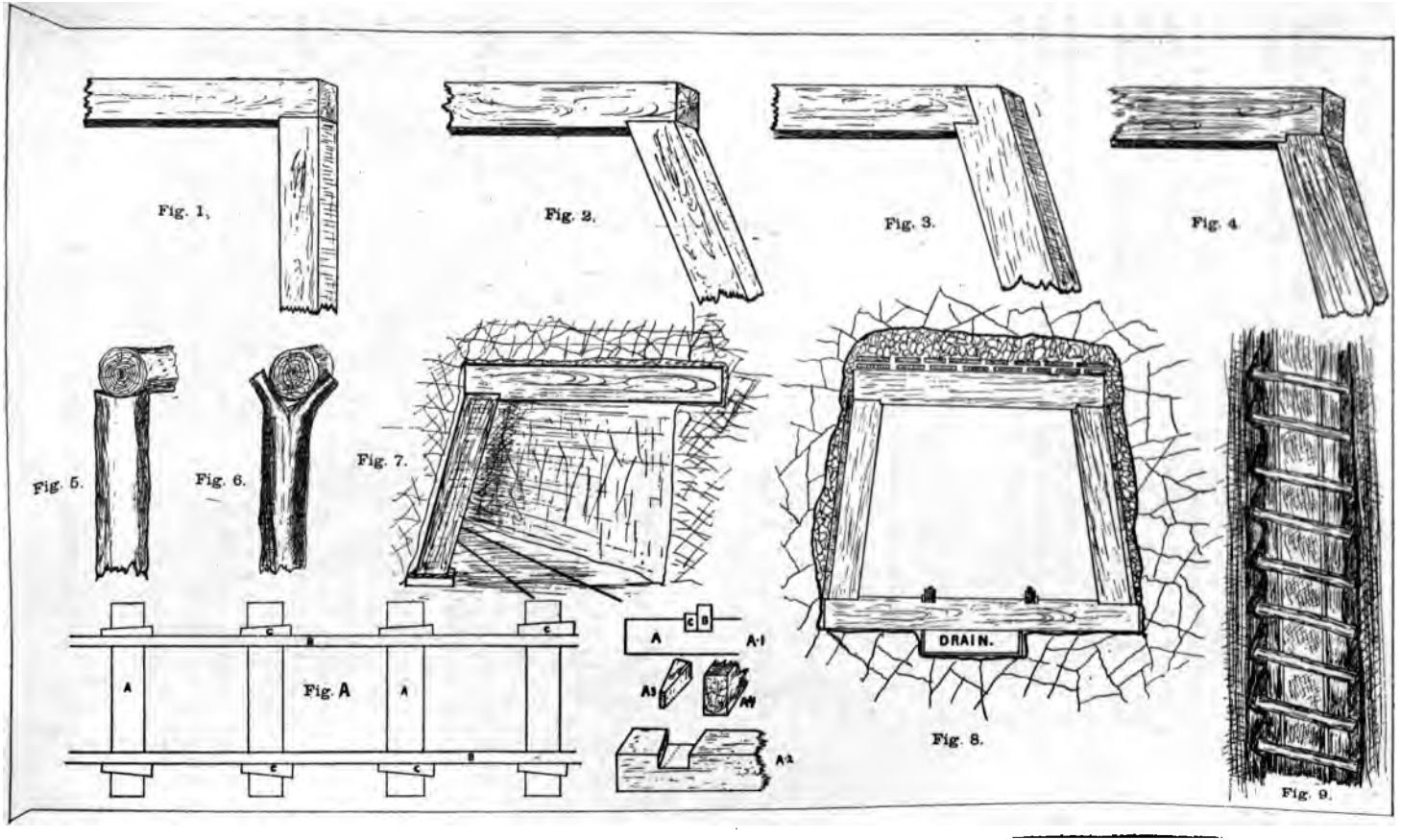


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
DRAIN.
Fig. 8.
Fig. 9.
Fig. A
A
B
C
A-1
A-2
A-3
A-4

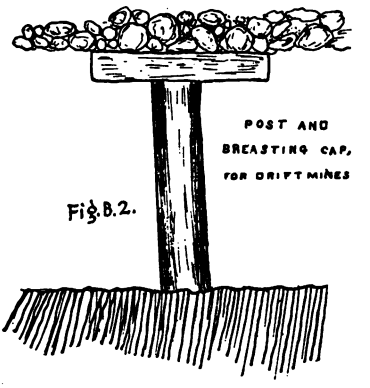


Fig. 8.2.

·y often pressure is exerted from the sides as well as from the top rift. In such cases the timbers are framed with a view to binding more firmly together when in place. (Fig. 8.)

s. 1, 2, 3, and 4 show several styles ming timbers for drifts. Of these t is undoubtedly the best. Better any of these is the beveled notch, ı greatly reduces the liability of the rs splitting. It has come quite sively into use of late years. When rly framed and set there is little r of slipping. Still another, and no the best method of all, has lately into practice. It is that of nailing ch plank on the under side of the By this device the fullest strength timbers is obtained, with no proba- of splitting.

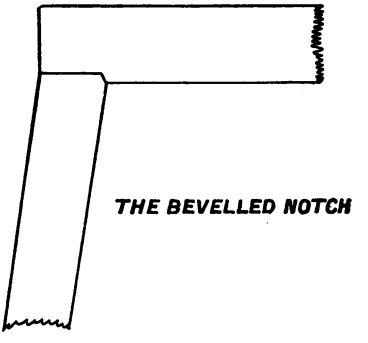


Fig. 9 A.

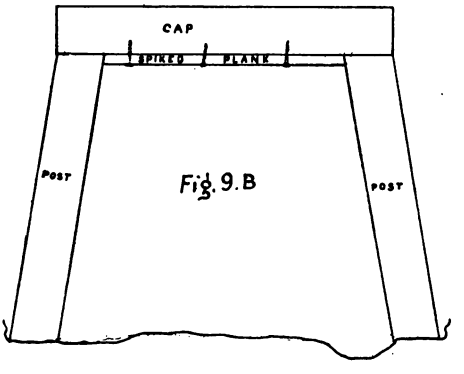
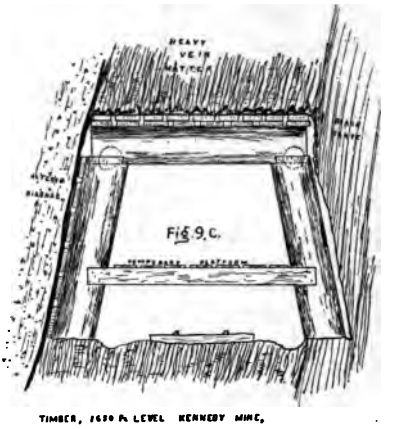


Fig. 9.B

ıen round timbers are used they should always be stripped of the or they will speedily decay. The manner of framing timbers is the whether they be round, hewn, or sawed.

Figures 5 and 6 show a method of placing posts and caps. It is seldom seen now. There is nothing about it to recommend it. Oak is the only timber that may be safely employed in this manner, pine being too soft and quite certain to split.

Where one side of a drift only and the roof need support, the post and cap (Fig. 7) is sometimes employed, One end of the cap rests upon the post, the other on a shelf, or niche, cut in the opposite wall.



TIMBER, 1650 Ft. LEVEL KENNEDY MINE, AMADOR Co. CAL.

LAGGING.

When the roof or side of a tunnel is loose and shows any tendency to cave, sprawl off, or run, lagging must be employed. Lagging is the name given to strips of wood 4 to 6 feet long, 6 to 8 inches wide, and 2 to 2½ inches thick. They are usually split from pine logs, but sometimes 2-inch plank 6 inches in width is substituted. In large shafts in heavy ground 3-inch plank is sometimes employed. The methods of driving lagging are shown in Figs. 10 and 12. The pieces of lagging are inserted over the top of the cap, the ends pointed upward a few degrees. They are driven forward as the work of excavation progresses, when there is danger of caving. Not infrequently ground will stand for many hours and sometimes for months before caving, but it is cheaper to timber very soon after the excavation has been made, in order to keep the ground in normal condition, giving it no chance.

The two systems shown in Figs. 10 and 12, while the same in principle, differ materially in detail. In Fig. 10 the lagging is inserted between two caps which are separated by wedge-shaped blocks, one of which is placed in the center and one at either end. (See between A and C, Fig. 11.) The lagging is driven forward as explained. If the ground is very heavy a "false set" (Fig. 12) is set up and the ends of the lagging rest upon it. The excavation progressing and the lagging being driven well forward, the next set is put in position and the lagging driven "home," that is, until the forward ends find a secure resting place on the true set. The false set is then knocked out and the same procedure gone through with the next set.

The only difference between Fig. 10 and Fig. 12 is that in the former *there are two caps,* as explained above, while in Fig. 12 the lagging is

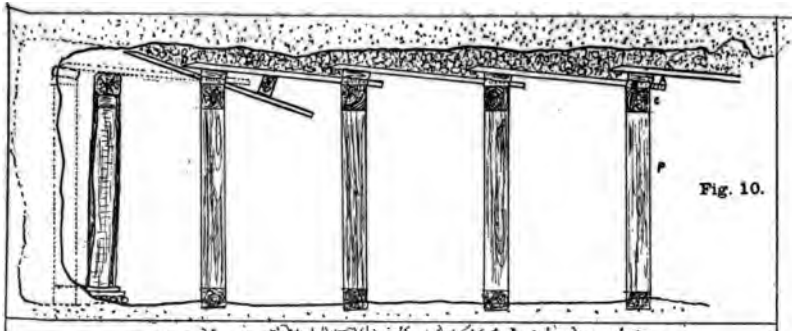


Fig. 10.

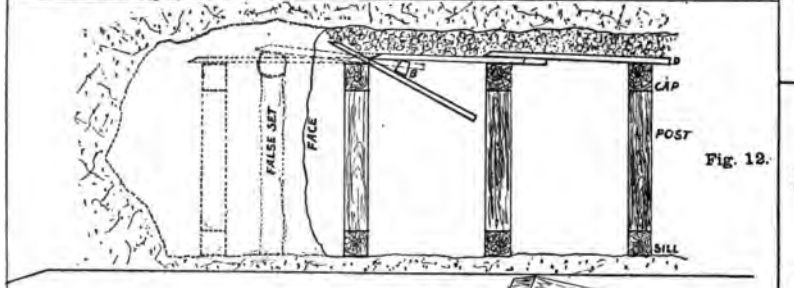
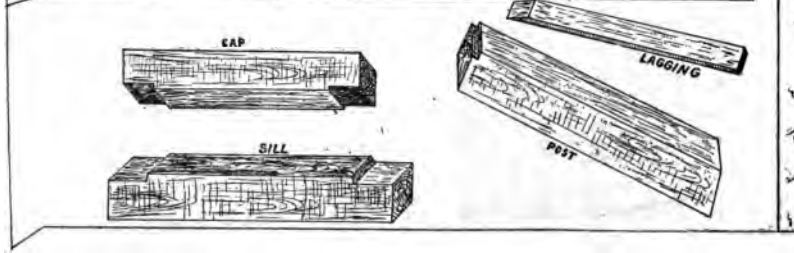


Fig. 12.



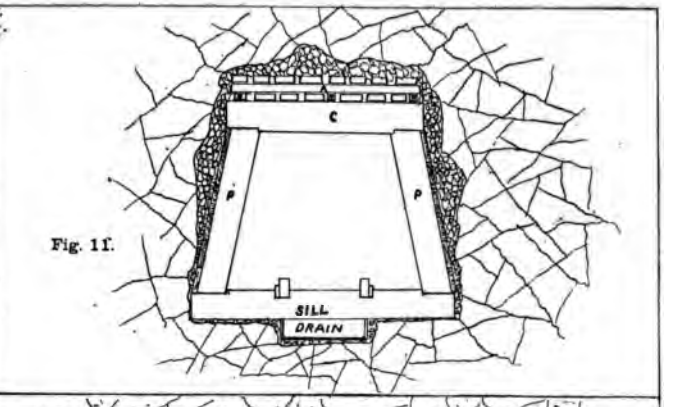


Fig. 11.

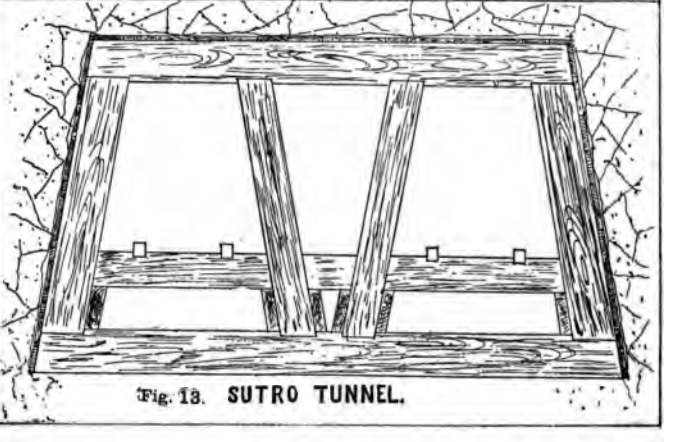


Fig. 13. SUTRO TUNNEL.

inserted beneath the forward ends of the next set back. In each case the lagging is kept pointed slightly upward by the insertion of a block of wood shown at B, Fig. 12. When the forward ends of the lagging rest on the false set this block may be allowed to drop out. The system shown in Fig. 10 can be employed much more advantageously and work progress more rapidly in very heavy ground, than when that shown in Fig. 12 is used, which does very well in lighter ground. Where the ground is very bad the lagging must be kept driven as far forward as possible. By observing care in this matter serious runs are sometimes prevented. Sills are only employed when the bottom of the tunnel does not afford a firm foundation for the posts.

For lagging, spruce, yellow pine, and tamarack are much used, but the sugar pine of California has no superior for toughness and durability. Lagging should not be too strong, for in the event of extreme weight it should bend and give notice of impending danger. The miner may then relieve the pressure by cutting away a portion and reinforcing the timbers, thus saving the more expensive framed timbers and perhaps preventing a serious cave.

Caps and posts are all sizes from 4x4 or 4x6 inches up to 24x30 inches, according to the size of the excavation and the character of the ground. Caps should be free from knots and checks as far as possible. Less care is necessary in the selection of posts, though all timbers should be of good, sound wood. Sills extend somewhat beyond the posts which rest upon them. A shallow notch is usually cut in the sill to admit the post, the bottom of which is cut at right angles to its sides. (See the accompanying figure.)

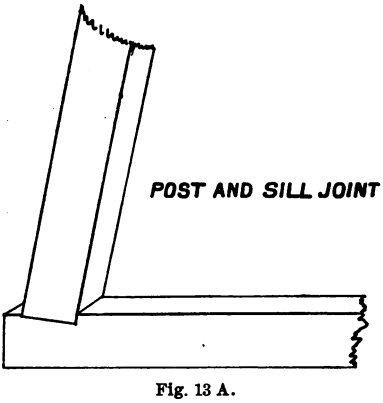


Fig. 13 A.

The greater care taken in framing and setting up mine timbers the less danger there will be of collapse in the future. The tools necessary to secure this exactness are a plumb-bob and a steel square. A spirit-level is also very useful.

TRACK-LAYING.

To construct a track, cross-ties, made of 3x4 scantling, are often laid on the floor of the tunnel or drift, and to these are spiked "T" rails. When flat iron is preferred a durable track for permanent use is made by setting long 2x4 scantling in slots sawed in the cross-ties, the long strips being secured by driving in wedges at the side. The details of track construction are shown in Figs. A, A1, A2, A3, and A4, which are on the same plate as Figs. 1 to 9. Upon the scantling-stringers may be spiked the flat iron, or if desired, "T" rail. The scantling should not be spiked to the cross-ties, as nails are quickly corroded by the mineral vapors and waters of mines.

DRAINAGE.

Provision for drainage should always be made at the very commencement of opening a mine, for, though the tunnel may be dry at its mouth, when it has been driven a long way into the mountain more or less water is nearly always encountered. A drain or trench should always be cut in the center or at the sides of every tunnel or drift. Illy drained workings cause the timbers to rot quickly, and also endanger the health of the miners. Neglect to provide drainage very often results in the necessity of retimbering, which expense might otherwise have been avoided for a long time.

Prospectors, in their haste to advance work as speedily and as cheaply as possible, frequently fail to timber properly and to provide for drainage, with disastrous results in the future. Many months of laborious toil are too often lost in this way, to say nothing of the loss of life and limb by the unfortunate miner caught in a cave which might have been easily avoided.

SWELLING GROUND.

One of the greatest difficulties with which miners have to contend is the swelling of the rock masses into which their excavations have penetrated. Often the force or pressure against timbers caused by the swelling of the ground is irresistible. It is a common feature of many of the Mother Lode mines in California, particularly in Tuolumne, Calaveras, and Amador Counties. Swelling bedrock is quite common in the gravel drift mines of California. All Comstock miners know what swelling ground is. It is one of the most serious obstacles with which they have to contend.

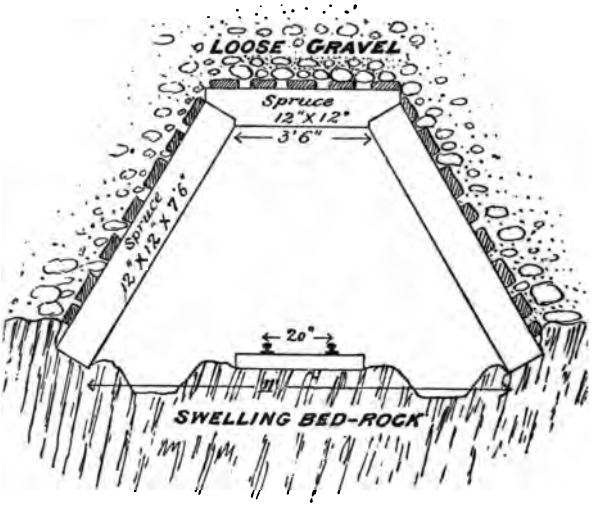
In a general way it may be said that the only recourse is to timber in the most substantial manner, and then, by frequently, or as often as necessary, cutting out a portion of the heavy ground and relieving the pressure the timbers may be kept in place and the excavation kept open. Fig. 14 represents a cross-section of a tunnel where this trouble in its worst form was encountered. By setting timbers in the manner shown in the cut, placing the sets close together, and relieving the ground by the removal of the encroaching portion from time to time, the trouble is reduced to a minimum. In the Hardenburg Mine, Amador County, swelling ground has caused a great deal of trouble lately. The 900-foot level is run in a zone of crushed foliated black slate, which, on the footwall side of the drift, when first broken, appears firm and solid, but in a few days it commences to spawl off and to noticeably encroach upon the drift. It continues to swell, displacing timbers or breaking them, and causing no end of trouble. Now such places are timbered with 18 and 20-inch round timber and somewhat loosely lagged. But few days pass before it is necessary to take out lagging and cut away the swelled ground.

In running the main tunnel of the Hidden Treasure Mine at Forest Hill, in Placer County, swelling bedrock was encountered. Mr. Ross E. Browne, E.M., in his article, "The ancient river beds of the Forest Hill Divide" (*vide* X report, State Mineralogist of California), says of this occurrence:

"The pressure of the gravel is not great, but the swelling bedrock has been a source of trouble, driving the legs of the timber-set inward and

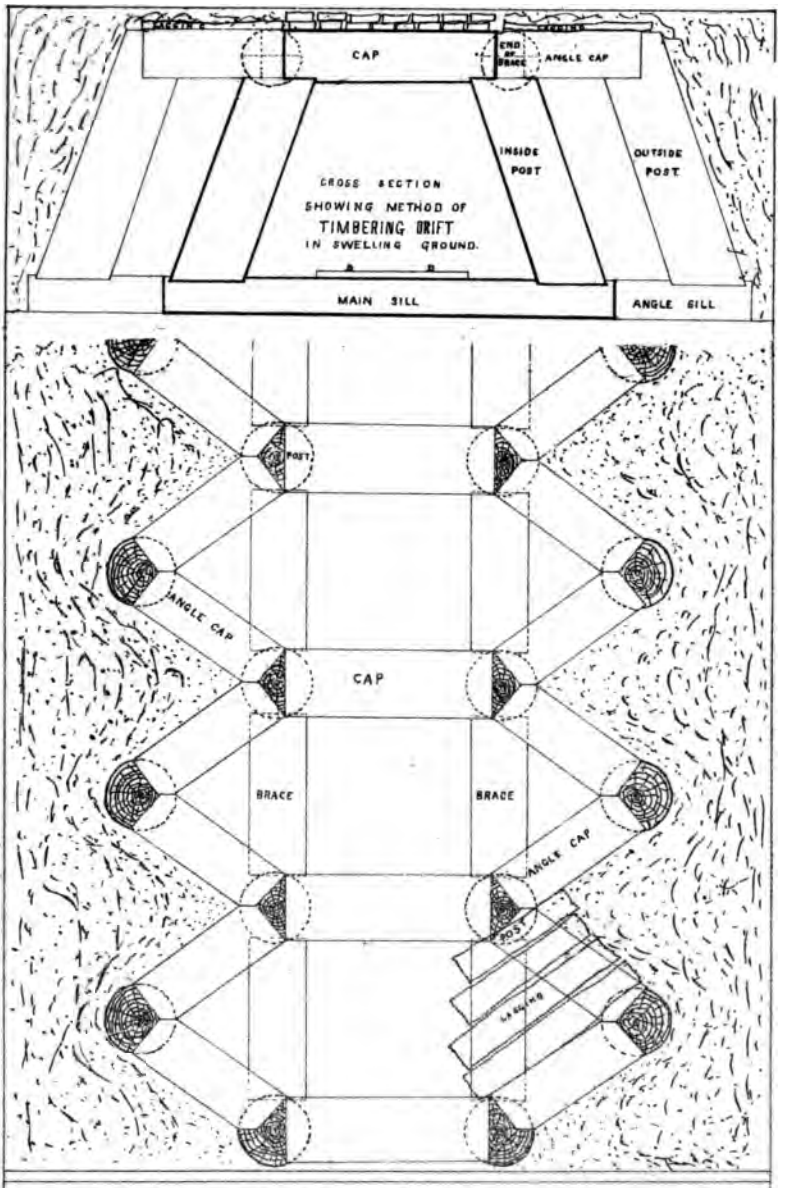
crushing the cap. After many unsuccessful attempts to overcome this difficulty, the legs were given an increasingly greater bottom spread, until finally it was found that they remained stationary. The swelling bedrock is removed from time to time and the track adjusted. The accompanying cut shows the form of tunnel timber-set now used in bad swelling ground. Sets are first put in 4 feet apart, and in the course of a few months center-sets are placed between these. Timber-sets on this plan have now been in place three years (1879), and are still in good condition. In 8,500 feet length of tunnel there are about 4,000 sets of timbers. Two men are kept constantly employed in easing and repairing the sets and adjusting the track."

Fig. 14.



Some of the drift mines on Sugar Loaf Mountain, near Nevada City, Cal., that were worked twenty-five years ago, were timbered in a very peculiar and unusual manner, owing to the swelling of the bedrock. Massive timbers had been placed time and again, only to be forced out of place, or broken. At last the method here described was introduced and found to answer every requirement most admirably. It was subsequently tried in some of the other mines of the neighborhood with equally satisfactory results. Once firmly placed, the timbers were never again renewed, standing until the mine was worked out.

The plan adopted was as follows: A drift of the usual form was run and heavily timbered, being well lagged overhead. The sets were placed 5 feet from center to center. As the work of excavating the drift proceeded, a triangular section was cut out of each side of the drift between the posts of the two adjoining sets. These two posts formed the base of a triangle, the apex being directly opposite the center of the base. At the apex a post was set, the center of which was 3 feet from the center line of the posts forming the base. Caps were placed reaching from the post at the apex to each of those of the base, and lagging *driven in diagonally* from the drift. The two sides of the triangular *section opposite the* base were lagged, a considerable space being left



METHOD OF TIMBERING SWELLING GROUND IN THE DRIFT MINES OF SUGAR LOAF MOUNTAIN, NEAR NEVADA CITY, CAL IN 1867-69.

Fig. 14.A

between the lagging to afford an opportunity for the soft swelling ground to force its way through the open spaces, when it is removed. These triangular spaces were continuous; that is, were cut opposite each set of the main drift. The method involved considerable extra expense in mining and timbering, but it was so infinitely superior to any plan previously tried that it was looked upon as a success mechanically and financially. The accompanying sketch will make plain the details of this peculiar method which since its use in the mines on Sugar Loaf Mountain, seems to have been lost sight of.

Drifts sometimes require but a few posts to support particular rock masses that threaten to fall. Where a post alone affords insufficient support, a heavy piece of plank (plate) is inserted between the top of the post and the roof.

RUNNING GROUND.

Tunnels and shafts at times must pass through soft, running ground. Zones of rock of this description are often found lying between walls of firmer rock. The occurrence is not infrequent on the Mother Lode of California when the fissure is barren of quartz and filled with a mass of soft crushed foliated black slate. It is prominent in the Quaker City, Gwin, Hardenburg, Kennedy, and many other mines on the lode. Such ground is nearly always wet, and the process of sinking or drifting in it is attended with expense and danger. In sinking through such ground the miners usually make an effort to push the work and pass through it as quickly as possible. When the ground is very wet and runs easily it is not always the best plan to "crowd" it. In some cases the difficulties are more easily overcome, the expense reduced, and the completion of the task sooner accomplished by going slowly, allowing the ground to assume a more normal condition by cutting out and removing the material falling into or forced into the excavation. When water is troublesome in ground of this character, the better plan is to permit it to drain off. By so doing the ground sometimes becomes firmer, and, as a consequence, is more easily handled, timbers more readily placed in position, and the work carried on more satisfactorily.

Another kind of ground difficult to timber is found in some much altered rocks where talc, steatite (soapstone), and serpentine, containing much water, have to be passed through. The ground often breaks well and sometimes stands well for a time, but it is treacherous and should be promptly and substantially timbered. Rocks of this description are abundant in the great auriferous belt of California, and as miners there well know, are usually fissured in every direction and upon exposure to the atmosphere exhibit a tendency to break up (called blocky ground). Great angular blocks and "heads" (round bowlders) drop from the roof and sides without warning. The former are often wedge-shaped and slip out from the fissured rocks when the ground had appeared firm and solid. The heads are usually hard in the center, while the outer portion is quite soft, feeling greasy to the touch. In size these masses range from an inch or two in diameter to those which weigh tons. Timber must be placed in ground like this immediately as the work progresses. The sets should not be more than 2½ feet from center to center, instead of the usual distance, 4 to 5 feet, whether it be in shaft or tunnel. Lagging, when used, must also be short.

When passing through slips or fissures, whether single or in zones, in

any kind of rock, extraordinary precautions should be taken, as accident is much more likely to occur at such points than in solid, unfissured ground. Rock in the vicinity of veins is nearly always more dangerous than that at a distance from the vein.

SHAFTS.

Working shafts, as well as tunnels and drifts, should be arranged with a view to securing their permanency. Indeed, in consideration of future possibilities, even greater care should be exercised in the selection of their location and in deciding upon their size, while the manner of timbering is most important. Working shafts should be so equipped as to remain open and be in use as long as ore remains in the mine which it will pay to extract. As in all other mine work, the amount of timber required depends largely on the size of the shaft and more particularly on the character of the rock through which it passes. Prospecting shafts are sometimes sunk in good-standing ground to the depth of several hundred feet without other timber than a few stulls, to which ladders are secured. The few timbers thus placed often become insecure through neglect, particularly in regions where there are climatic alternations of wet and dry. When wet, the timbers and the wedges securing them, swell. With the change to dryness they shrink and are likely to drop out. An additional danger results when the rock walls crumble, and men working below are in constant danger from falling rocks and timbers. The wedges demand frequent attention, for they must be kept driven well in at all times. On the desert and in mines above timber line, where timber is expensive, miners endeavor to get along with as little as possible and are not very particular as to the kind and quality of that which is used. It would perhaps be a better plan to dispense with timber altogether than to place too much dependence on sticks that are likely to drop out of position unexpectedly. As a matter of fact, the writer has seen shafts in the Mojave Desert mines more than 200 feet in depth without a single stick of timber. The necessities of the case in sparsely timbered regions and on the desert have obliged the miner to resort to many novel plans to protect himself against danger at the least possible expense. He puts in as substantial a frame of timbers as he can obtain, or as he may think he can afford, using a few frail saplings, thin, split lagging, or even brush, to support the sides of his shaft. Fortunately for him, in the desert regions, where scarcity of timber forces upon him this economical "system" of timbering, the rock, being nearly always dry, stands fairly well, as a rule, and expensive timbering is not necessary.

The extremities to which prospectors are often reduced to procure timber in these timberless regions has resulted in the adoption of a method peculiar to such districts. While the result is not particularly pleasing from a workmanlike standpoint, it nevertheless exemplifies most faithfully those principles which are the foundation of the most elaborate system of timbering. In these shafts all timbers are stulls, each one being placed to support some particular rock or mass which seemingly threatens to fall. Each stick is independent of the others; there are no *superfluous timbers*, and no attempt at system or regularity. As a result

these sticks cross the shaft at many angles. Some are horizontal, but most of them inclined somewhat from that position. It sometimes gives the shaft timbers a spiral appearance as viewed from above. Despite the fact that these timbers are placed so much at variance with recognized methods, if placed at the time of making the excavation, or shortly thereafter, and are properly and firmly wedged, they usually render the shaft fairly safe. In that region old redwood railroad ties are very frequently used for mine timbers, and answer admirably, even though unsuited for such use from having lain for months in a railroad bed, being split and often cut by the rails. The miners are glad to get them, poor as the timber is, for when once properly placed they have been found to do very well, where the pressure is not too great.

Shafts having a single compartment, such as are frequently seen in small mines, are timbered in a simple manner. The timbers consist of two wall and two end plates and four posts to each set. The method shown in Fig. 14 C is quite common and suited to shafts of moderate size (5x7 in the clear), having a single compartment. The four frame timbers are placed in position and tightly wedged, the posts being driven in at the corners. Care must be taken to keep the sets in line. Sets are ordinarily 5 feet apart from center to center. When the ground is heavy, sets may be placed closer than 5 feet. They are often only half that distance from center to center.

Lagging, either split or sawed (2-inch plank), is driven in behind the timbers. It is driven one half to three quarters of the way down, when the lower ends of the next set below are inserted between the timber and the wall. Later the lagging of the set above is driven down to its proper place.

CRIBBED SHAFT.

When the pressure of the ground is very heavy a crib of timbers is built, the timbers being placed one on another with only a notch at the ends to hold them in place. In soft ground it may be necessary to use lagging, even in a cribbed shaft. All open spaces between the walls and the crib or lagging should be filled with broken rock to secure firmness, and to counteract any tendency of the timbers to shift. The manner of framing crib timbers is shown in the cut on page 18.

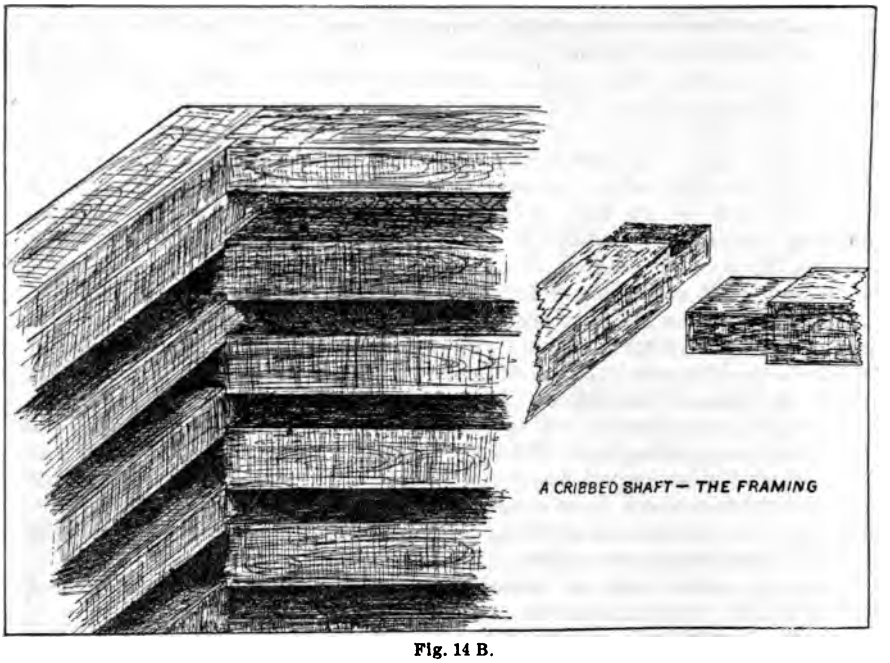


Fig. 14 B.

REACHERS IN SHAFTS.

When sinking can be carried on somewhat in advance of timbering, it is sometimes the custom, in firm ground, to place long timbers, called "reachers," across the shaft, the ends resting in niches cut in the walls. These having been firmly placed, the four timbers of the set are laid upon them and firmly wedged, and from this foundation the sets are built upward to the next set of reachers above, a distance of 25 to 30 feet. Where the shaft is sunk in country rock, or in a large pillar of ore (the latter to be avoided when possible), the reachers are placed alternately in sets at right angles.

The manner of framing the ends of shaft timbers where they join at the corners is shown in the cuts of the Requa, Forman, and Alma shafts and the Argonaut incline.

Men working in shafts placing timbers usually work suspended on slings secured to timbers above.

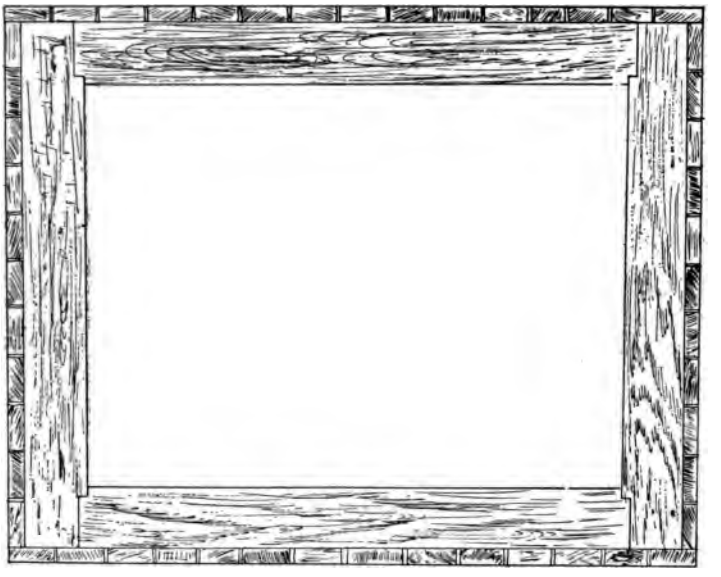


Fig. 14 C.

IRON DOGS AND BOLTS.

In places where the above described methods of building sets of shaft timbers on reachers is not possible, owing to the soft nature of the rock in which the shaft is sunk, or where it is desirable to run cages to the bottom of the mine, it was formerly the custom to suspend the shaft timbers by ropes in a position as near to that desired as possible, and to then maintain them in that position by driving iron dogs into the timbers, the weight being supported by the set next above, which had previously been secured by wedges. In some cases these dogs were never removed. Many of them may be seen in the older California mines. The dogs were made of round or square iron bars 1x1 inch or 1x1½ inches, and having the ends turned at right angles. The points were 3 or 4 inches in length and sharp. The length of the dog was determined by the distance from center to center of the sets.

When the rock was sufficiently firm to admit of the timbers being firmly wedged the dogs were knocked out. Iron dogs or bolts are useless as a means of support when the surrounding rock masses have once firmly settled on the timbers.

A safer and more convenient device has been introduced in later years, in the form of iron bars having a thread at one end and a ring or hook at the other. These go in pairs, their combined length exceeding by 6 inches the distance from the top of one set to the bottom of the next set beneath. The manner of using these hangers is as follows: A set having been securely wedged in its proper position, the threaded end of the bolt provided with a hook is passed upward through a hole in the plate (bored in all timbers for the purpose), a washer passed over the end of the bolt, and a threaded nut screwed down onto it. A second "lock-nut" may be used, but is not necessary. A second similar bolt with

hook is passed through a hole near the opposite end of the same timber, and also secured with washer and nut. The timber to be placed directly below is suspended by ropes in a position approximating that desired and a bolt having a ring at one end is passed downward through this timber, immediately below that in the timber above, and a similar bolt is passed through the opposite end. Washers and nuts are placed on the ends of these bolts and the rings are caught in the hooks of the bolts above. The nuts may now be turned and the timber drawn to exactly the position required, when the ropes may be removed. All four of the timbers of this set having been placed in position, and being suspended on the hangers, the posts are slipped in, the nuts tightened still further, and the whole firmly wedged, when the next set below may be put in in like manner. The hangers are left a few days or weeks, and in some instances permanently, but, as previously stated, they are useless as a means of support when the weight of the surrounding rock has settled on the timbers.

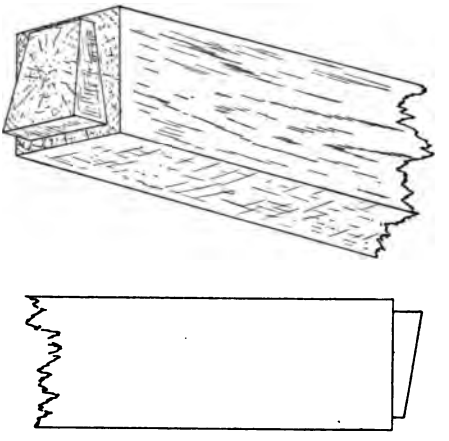
Where, owing to the soft nature of the ground, it is thought desirable to have the hangers remain in place indefinitely, a bar having a thread at one end and simply turned at a right angle at the other, or having a solid hammered head with a washer, may be used, being passed upward through the bottom timber and then through that above, where the adjustment is made by means of a washer and nut; but as these bars are longer than the distance between sets, their removal is impossible, a set below once having been put in place. There is no question as to the superiority of the bolts having rings and hooks for either temporary or permanent use.

RETIMBERING SHAFTS.

It very frequently occurs that shaft timbers have to be removed and new ones inserted, and also often necessary to reinforce timbers already in place. This work frequently necessitates the suspension of hoisting through the shaft. The Superintendent of the Wildman Mine, at Sutter Creek, Amador County, California, having occasion to retimber the shaft between the 500 and 600 levels of the mine, constructed a chute 1 foot square of 2-inch plank in one corner of a compartment of the shaft reaching between these levels. It was built in short sections, each the length of a set of timbers. The work of retimbering was commenced above and carried downward, all of the refuse rock, timber, etc., being dumped into the chute. This material was taken up on the 600 level, dumped into a skip from time to time, and sent to the surface; by this means the work was quickly and safely carried on, sections of the chute being removed to keep pace with the work. By means of this device there was very little delay in operating the skips, and hoisting of ore was continued almost without interruption during the retimbering of that portion of the shaft.

SHAFTS HAVING TWO OR MORE COMPARTMENTS.

Large shafts are separated into two or more compartments by placing timbers called "dividers" at intermediate points between the end plates. They reach from the wall plate on one side to that on the opposite side *of the shaft.* These dividers are framed with a short beveled tenon, *broader at the top* than at the bottom. (See cuts of Forman, Requa,



MANNER OF FRAMING DIVIDER.

and Alma shafts.) These tenons fit exactly into mortices or notches in the wall plates. At each of the four corners of the shaft and between the wall plates, opposite each divider, is placed a post, which is set in a shallow notch or seat cut in the plates. In size the posts may equal that of the plates, or if desired they may be of smaller dimensions. The dividers are made the same depth as the wall plates, but are usually narrower across the upper face.

The dividers separating shafts into two or more compartments may be made most secure by permitting the upper portion of the beveled tenon to extend into the wall plate 2 or 3 inches, the bottom portion being let in but 1 inch. The post setting directly on the divider holds it much more firmly, and the danger of having the dividers knocked out by shots fired directly blow is greatly decreased, if not obviated entirely. It not infrequently occurs when dividers are framed so as to set but 1 inch into the wall plates a heavy blast will tear them out altogether, incurring expense of timber and time, which may be avoided in the manner stated above.

Drawings of two Comstock shafts illustrate the manner of framing and placing timbers in them. One of these is called an "L" shaft, and was sunk by the Overman and Caledonia companies jointly. It is known as the Forman shaft. The other is the Requa shaft, sunk by the Chollar, Norcross, and Savage companies. It is a large rectangular shaft having four compartments, and is a splendid example of its kind. An illustration of the new Alma shaft at Jackson, Amador County, California, shows a different style of framing. In fact, the manner of framing and joining the timbers of these three shafts is totally different.

In size, shaft timbers range from 8x8 to 20x24, and even larger dimensions are sometimes employed in very heavy ground, particularly in inclined shafts. The wall plates are usually broader on one side than on the other, and are placed in position with broad side up. End plates are usually the square of the smaller dimension of the wall plate.

Pumping and manway compartments do not require lining, but hoisting compartments, particularly where cages are run, should be lined throughout to prevent accident to men who sometimes overcrowd a cage.

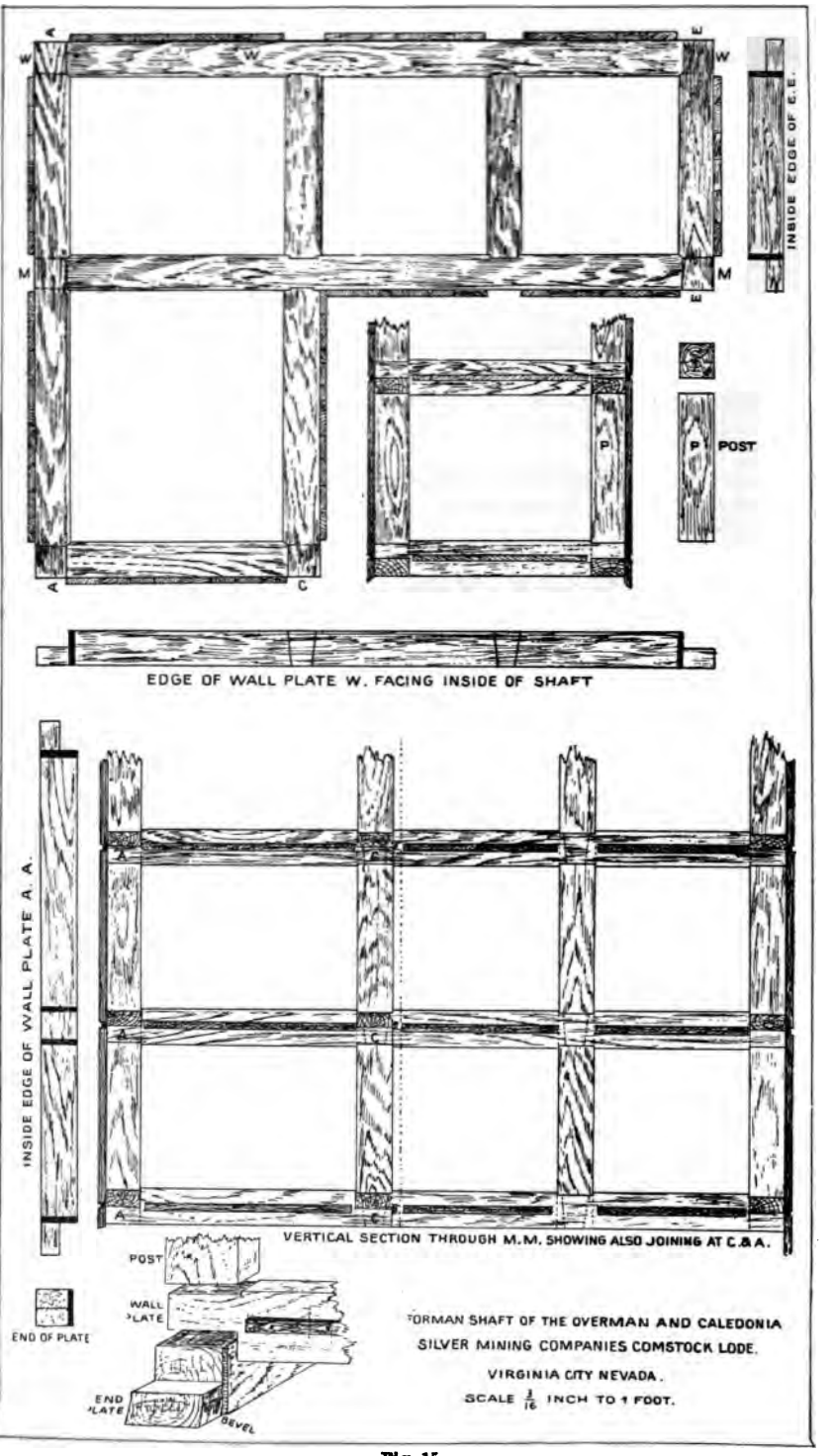

INSIDE EDGE OF E.E.
POST
EDGE OF WALL PLATE W. FACING INSIDE OF SHAFT
INSIDE EDGE OF WALL PLATE A. A.
VERTICAL SECTION THROUGH M.M. SHOWING ALSO JOINING AT C.& A.
POST
WALL PLATE
END OF PLATE
END PLATE
BEVEL
FORMAN SHAFT OF THE OVERMAN AND CALEDONIA SILVER MINING COMPANIES COMSTOCK LODE.
VIRGINIA CITY NEVADA.
SCALE 1/16 INCH TO 1 FOOT.

Fig. 15.

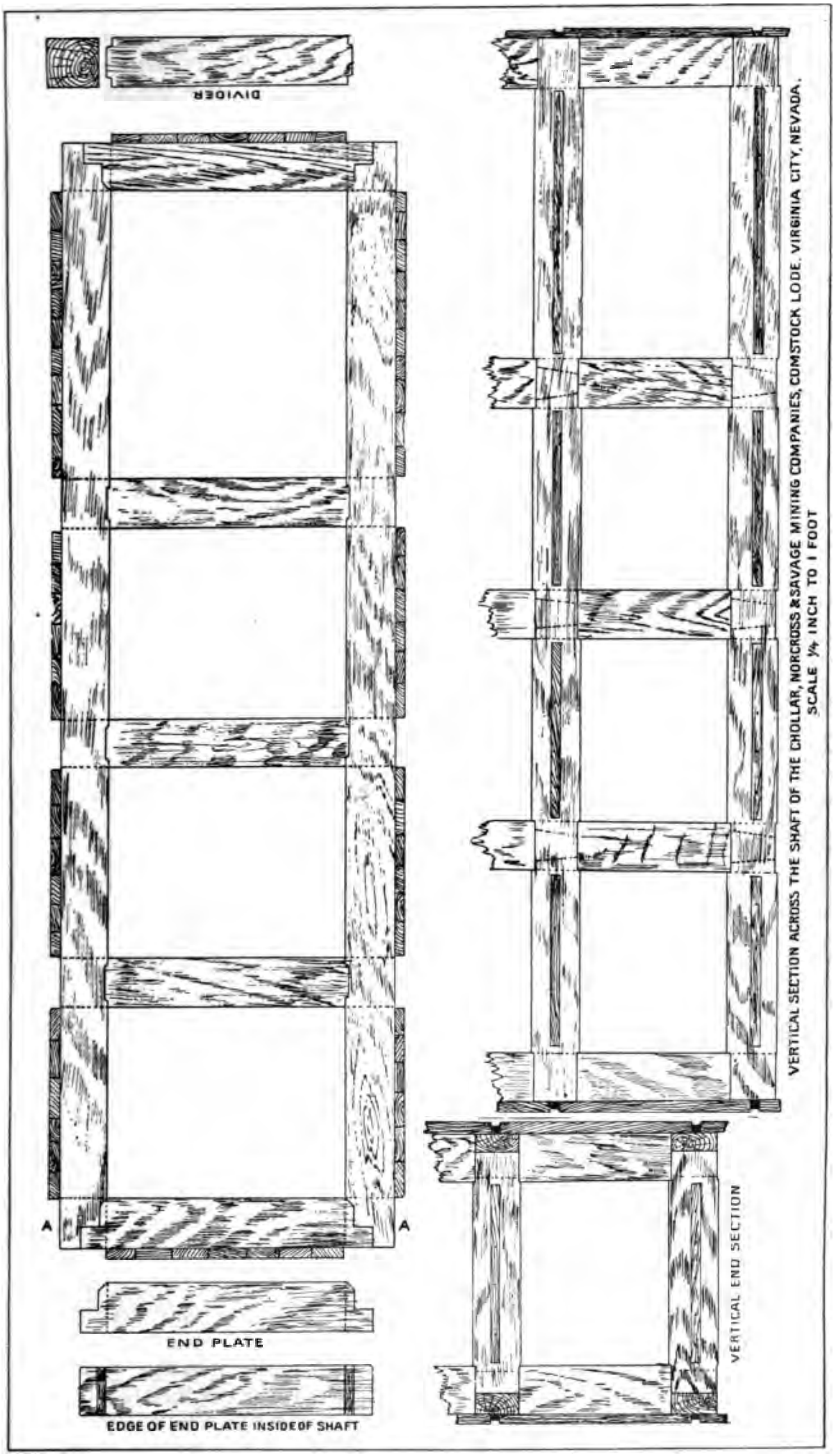

DIVIDER
A
A
END PLATE
EDGE OF END PLATE INSIDE OF SHAFT
VERTICAL SECTION ACROSS THE SHAFT OF THE CHOLLAR, NORCROSS & SAVAGE MINING COMPANIES, COMSTOCK LODE, VIRGINIA CITY, NEVADA.
SCALE ¼ INCH TO 1 FOOT
VERTICAL END SECTION

Fig. 15 A.

There appears to be less danger of this where buckets or skips are used. Every shaft in a mine should be provided with ladder ways as a means of exit in case of accident to shaft or hoisting machinery.

Sinking large shafts in swelling ground, in loose, watery, running ground, or in quicksand greatly multiplies the difficulties and dangers of the miner. There are instances where shafts have been abandoned owing to insurmountable obstacles which a combination of engineering skill, capital, and labor were unable to overcome, but such instances are of rare occurrence. Few shafts present greater difficulties than were encountered at Leadville, Colorado; in the Lake Superior region; in some coal mines; on the Comstock, and in Calaveras and Amador Counties, California (the latter are mostly inclines), and some of the shafts in the regions mentioned are to-day splendid and substantial monuments to American engineering and to the enterprise of the companies owning them.

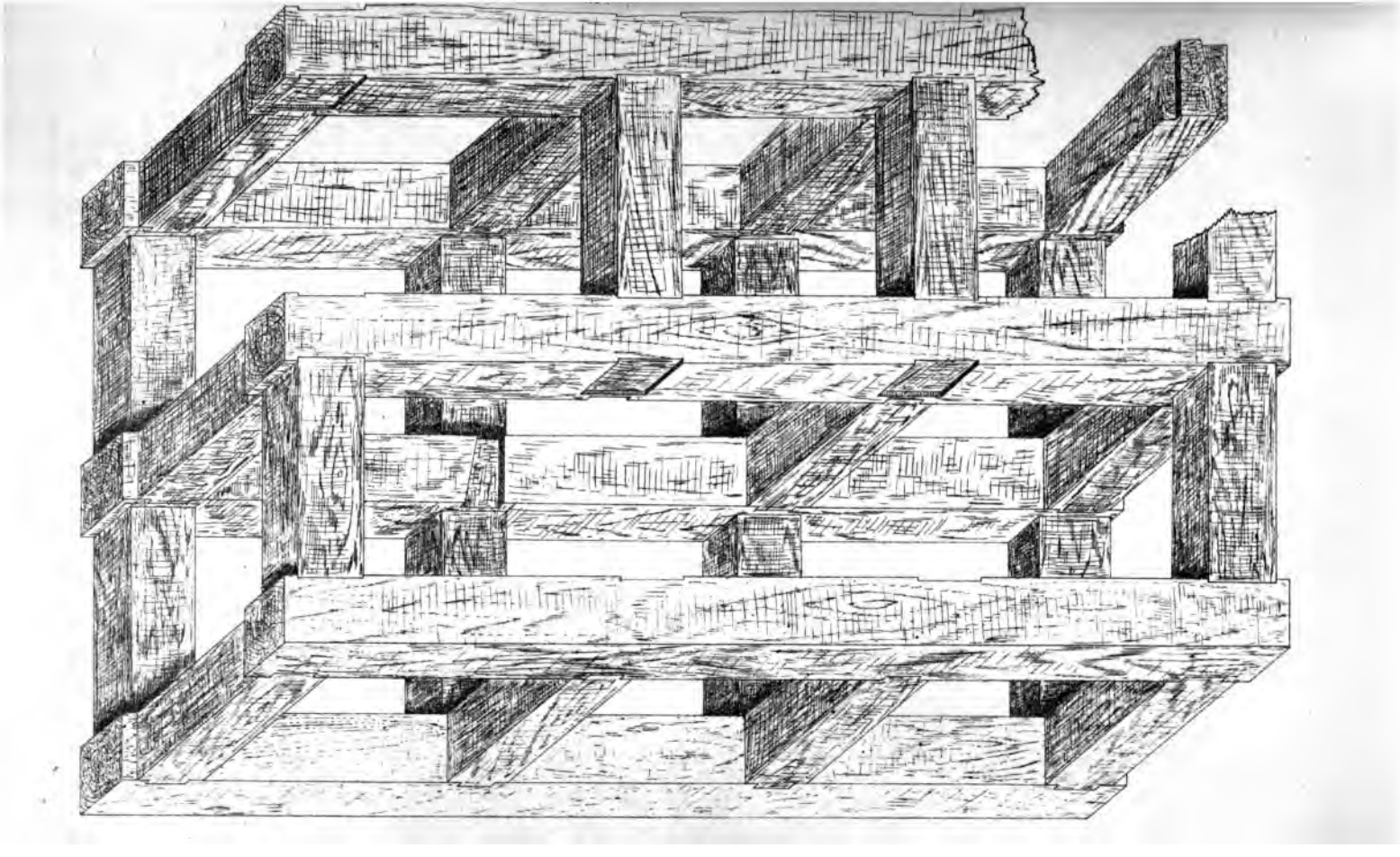
The shaft of El Capitan Mine, Nevada County, now the property of the Providence Mining Company, was sunk through decomposed slate and altered dyke rock under the most trying and dangerous conditions. After several failures, the shaft was carried down to solid ground under the direction of Francis Burns, who worked slowly and carefully, giving the soft running ground time to drain. The water being pumped from the sump, after standing for a time, appeared to drain the ground, and it was found that by this means progress was much more rapid than when the work was hurried. "Breast-boards" were carried down until the dangerous places had been safely passed.

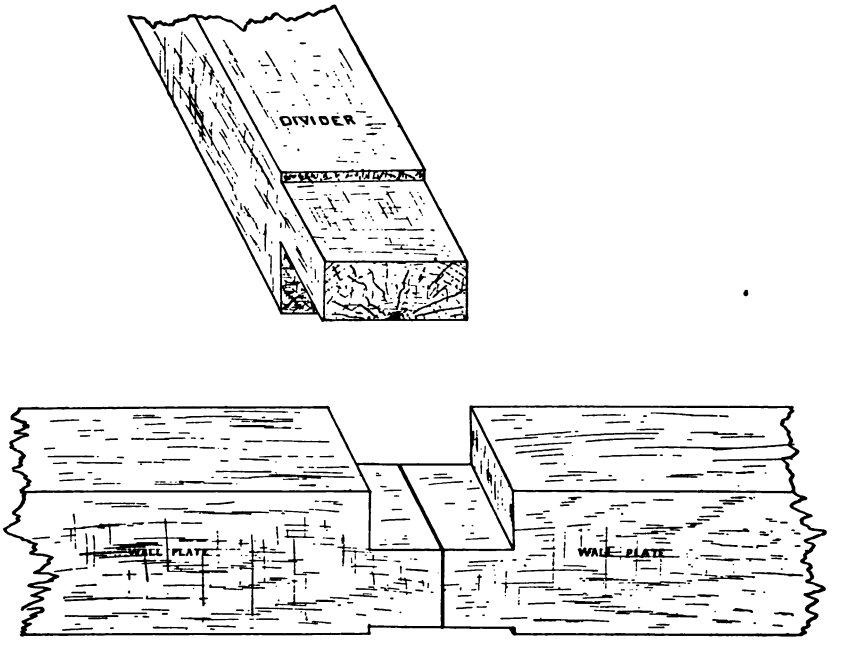
It is sometimes necessary in sinking large shafts to carry them down in sections by driving lagging or planks down in advance of the excavation. This is known as "fore-poling." The section is started at one end of the main opening and advanced several feet, the lagging being well braced. Considerable water will drain into this depression, making the removal of the ground from the remainder of the shaft much easier. By carrying one side of the shaft somewhat in advance of the remainder, in this manner, loose, wet ground can be worked more quickly and at less expense than when it is attempted to carry down the entire shaft at once.

SPLICED WALL PLATES.

In cases where sinking cannot be carried on in shafts much in advance of timbering the wall plates may be spliced. The better plan is to extend the plate from one side entirely across the two hoisting compartments, that portion in the pumping compartment being in a single piece, and joining the longer piece directly opposite the divider next to the pumping compartment. These joining ends of the two sections of wall plate should be framed so as to permit the divider to lap over their entire width, the upper half of the plate sections being removed so as to admit the upper half of the divider, as shown in the illustration.

The post standing immediately upon the divider, and covering the entire splice and overlap, prevents the divider from being blown out by heavy shots below. This plan also greatly facilitates the placing of shaft timbers, as there is not that great loss of time in getting the wall plates in position, which results when long timbers are handled. There *is always difficulty* and loss of time where the shaft cannot be carried





FRAMING FOR SPLICED WALL PLATE AND OVERLAPPING DIVIDER.
FOR SHAFTS.

down in advance of the timbers far enough to give room to turn the long wall plates. This system also permits of the renewal of wall plates and other shaft timbers by the ease with which they may all be removed.

BREAST BOARDS.

When the ground has a tendency to thrust itself up in the bottom of the shaft, the plan of planking and bracing the ground is sometimes resorted to. (The same principle is applied in drifting, when the method is referred to as "carrying breast boards.") In this method lagging is driven down in advance of the sinking, being supported in position above by a frame of timbers, either permanent or temporary. Planks are laid on the bottom of the shaft, being secured by upright posts, which abut against strong stulls or cross-pieces firmly wedged above. When the pressure from below begins to exert itself, a board near the center is removed and the soft, pulpy mass allowed to force itself upward. The material is removed until the ground is eased somewhat, when a second board is removed, the first being replaced somewhat lower than before, and again secured; the material coming up through this new space is removed as in the first instance, and in this manner work proceeds entirely across the excavation. The process is slow and requires considerable timber, but it is a plan which may prove successful when all others fail.

The method of driving lagging in shafts is similar to that explained under the *head of drifts*. (See Fig. 12.)

In some instances iron caissons have been sunk outside or inside the timbers to enable miners to pass through very loose, watery ground and quicksand. Where this is not absolutely necessary, wet places have been passed through by making a clay lining between two layers of close planking. It may be from 2 inches to 1 foot in thickness, according to the requirements. It has been successfully employed in passing through quicksand and watery, loose ground.

In very bad wet ground the idea is to form a caisson-like structure with lagging, the interior being sustained, as explained above, by massive timbers, so placed as to resist the pressure of the surrounding rock mass. The exigencies of each particular case must determine the course to be pursued.

The expedient of freezing soft, wet, running ground, quicksand, etc., is now much resorted to with great success. It is a patented process, but finds general use where applicable.

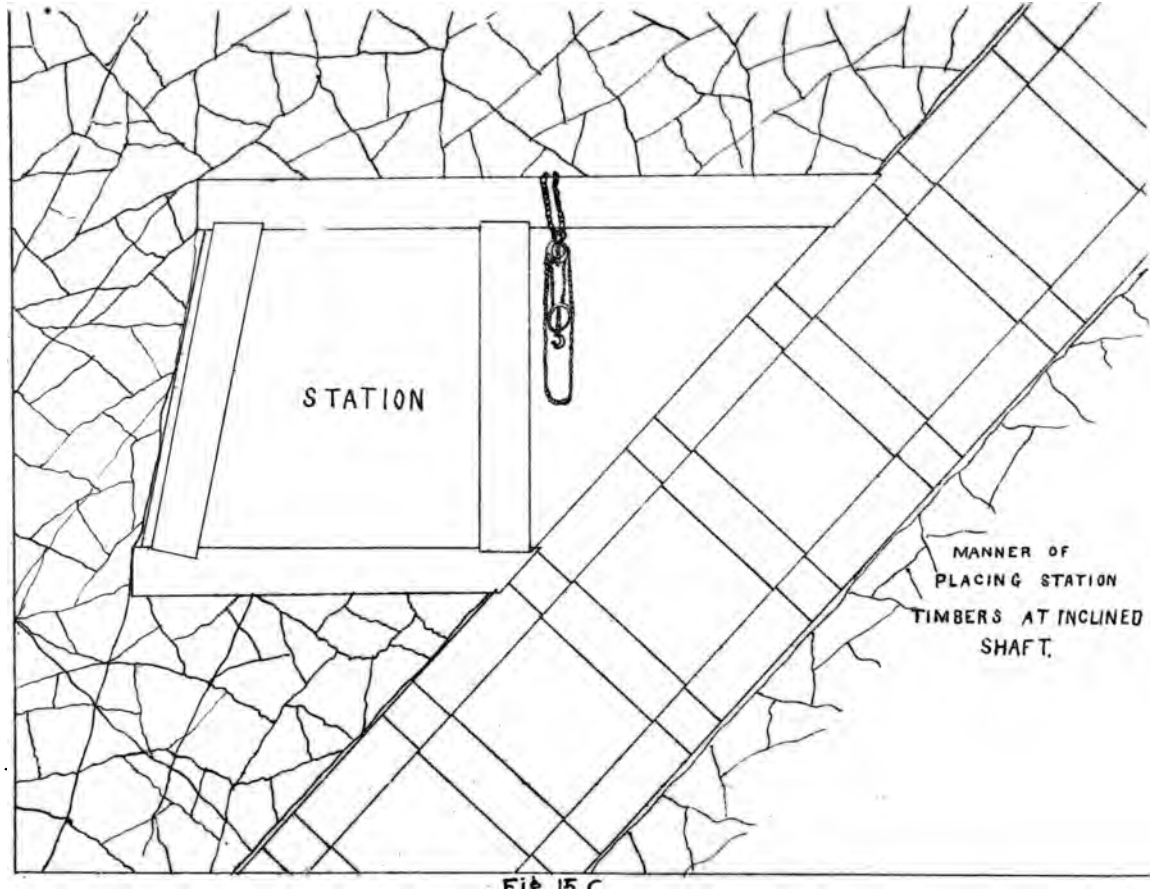
Circular shafts are seldom sunk in America now, though very common in the early days in California. There are circular shafts all through the old river-bed region, which pass down through the tufa capping without a single stick of timber from top to bottom. Many of them are over 250 feet in depth, and, notwithstanding they were made more than forty years ago, are still in good condition and likely to remain so for a century. The rectangular shaft is the most common form in this country. "L" shafts do not find much favor and have nothing to recommend them. The size and number of compartments of a shaft must be determined by the amount of hoisting expected to be done through it.

STATIONS.

The accompanying sketch shows the manner of placing timbers at a station in an inclined shaft. The method in perpendicular shafts is essentially the same. The chain blocks are for the purpose of landing timbers sent down in the skip.

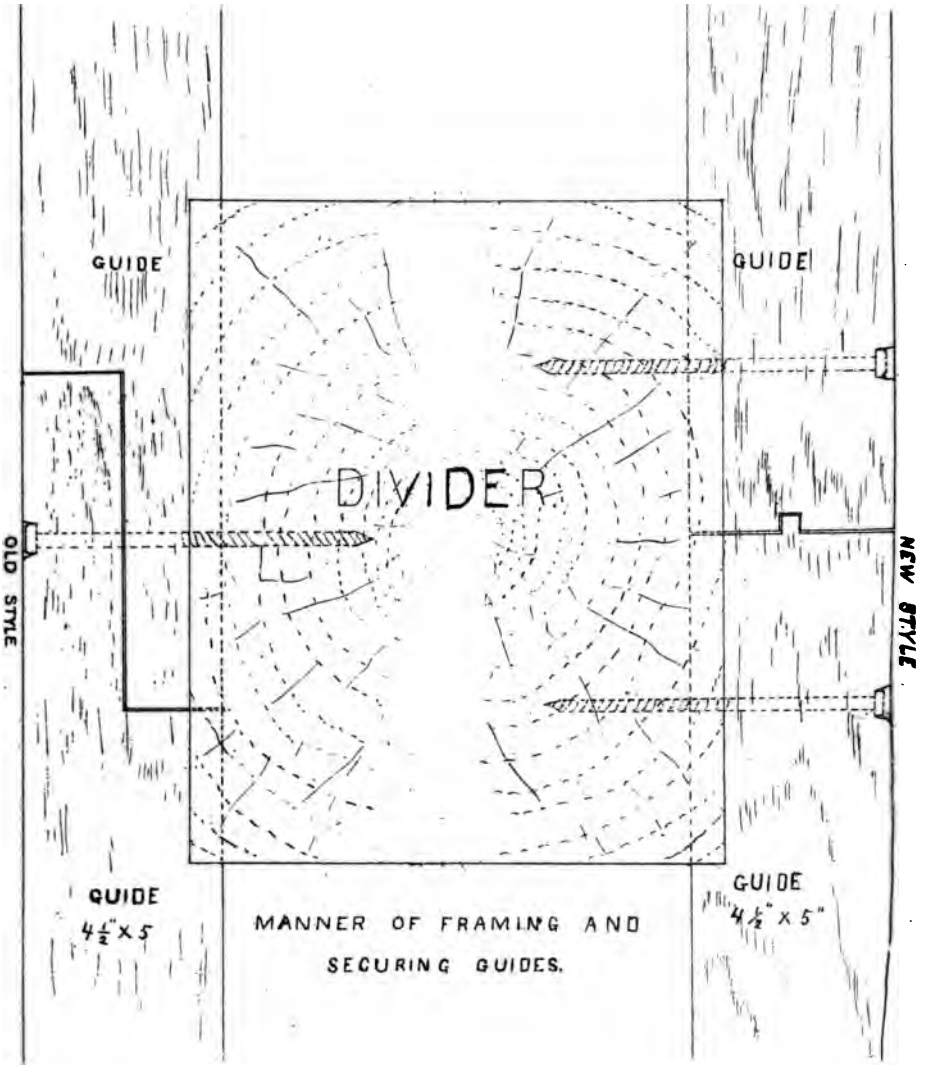
JOINING OF GUIDES IN SHAFTS.

Guides in shafts where cages are used or where skips run on guides should be so joined that there is no likelihood of their warping and projecting beyond their plane, and jam the cage, or skip, which is a most dangerous thing and a great strain on the cable. The overlapping of the ends has been for years a common practice; the two ends being secured at the overlap by a single lag bolt. An improvement has been made on this plan, with a view to greater safety, by joining the adjacent ends of sections with a simple tongue and groove, like ordinary flooring or wainscoting. The ends each have a lag bolt, which makes them doubly secure. The drawings show both styles for framing guides. Spikes or nails should never be used, as it requires much more time to remove a section when repairs are necessary. Guides are most easily repaired by laying a secure platform in the compartment at the point requiring repairs, the men working upward from set to set. Should the whole shaft, or any large portion of it, require new guides at any time, the platform should be put in as described. The hood is removed from the cage and a bottom *of loose boards* laid on the floor. The workmen at the platform unscrew *the lag bolts and* take out the old, worn guides. The cage being lowered



MANNER OF PLACING STATION TIMBERS AT INCLINED SHAFT.

Fig 15 C



MANNER OF FRAMING AND SECURING GUIDES.

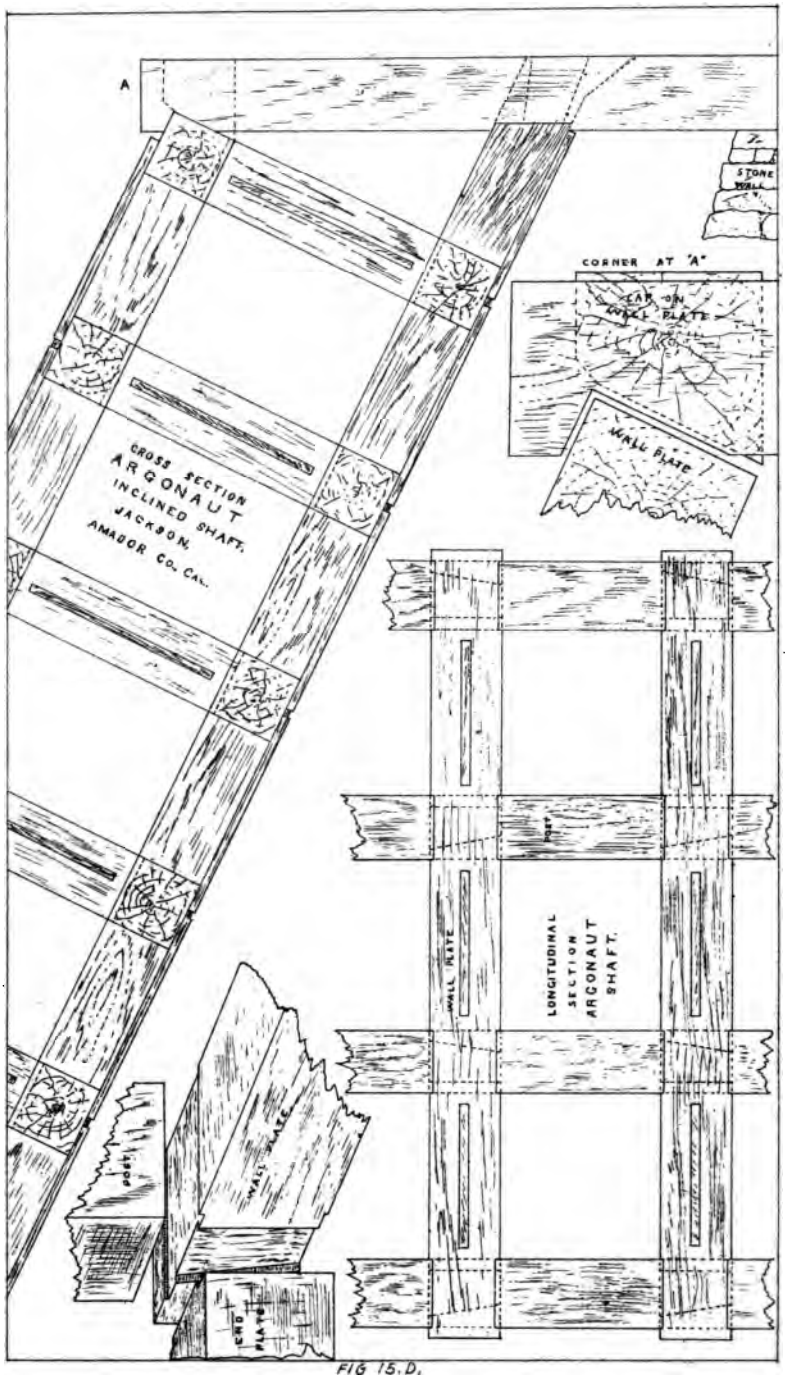
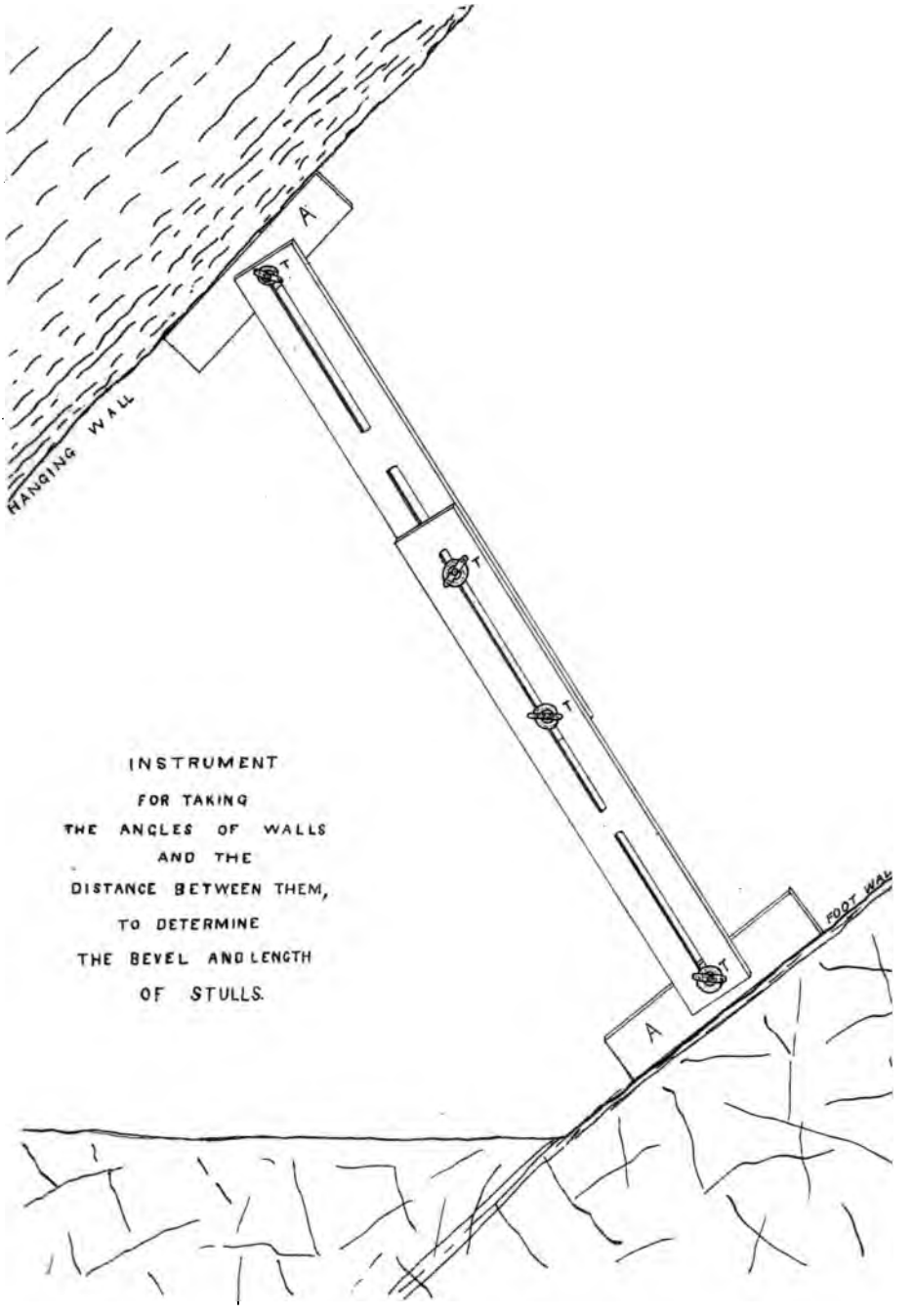

A
STONE WALL
CORNER AT "A"
CAP ON WALL PLATE
WALL PLATE
CROSS SECTION
ARGONAUT
INCLINED SHAFT.
JACKSON,
AMADOR CO. CAL.
POST
WALL PLATE
LONGITUDINAL
SECTION
ARGONAUT
SHAFT.
POST
WALL PLATE
END PLATE

FIG 15.D.



INSTRUMENT
FOR TAKING
THE ANGLES OF WALLS
AND THE
DISTANCE BETWEEN THEM,
TO DETERMINE
THE BEVEL AND LENGTH
OF STULLS.

to the proper point, the old guides are passed up through a hole made in the bottom of the cage, and the new guides passed down in the same manner and put in place. In this way the guides may be removed for a thousand feet in a single day by a gang of good workmen. Other repairs in the shaft may be made in a somewhat similar manner.

INCLINES.

Inclined shafts are somewhat different from those that are vertical, and are probably quite as numerous. In California the number of inclined shafts far exceeds those that are vertical, being, as a rule, sunk on the vein, which, in a majority of cases, dips at some angle from the horizontal. In a general way what has been said of vertical shafts applies to those that are inclined. There is considerable difference, however, in the manner of framing timbers for an incline, and while timbers framed for an incline will do, perhaps, equally well in a vertical shaft, those framed as already shown in the illustration are not preferred in an incline. An illustration of the method of framing timbers for the new Argonaut shaft at Jackson, Amador County, California, which is expected to reach a depth of 2,000 feet on the incline (63°), is given. It resembles somewhat the new Alma shaft, also at Jackson, though the first 400 or 500 feet of the Alma will be vertical.

STOPES AND CHAMBERS.

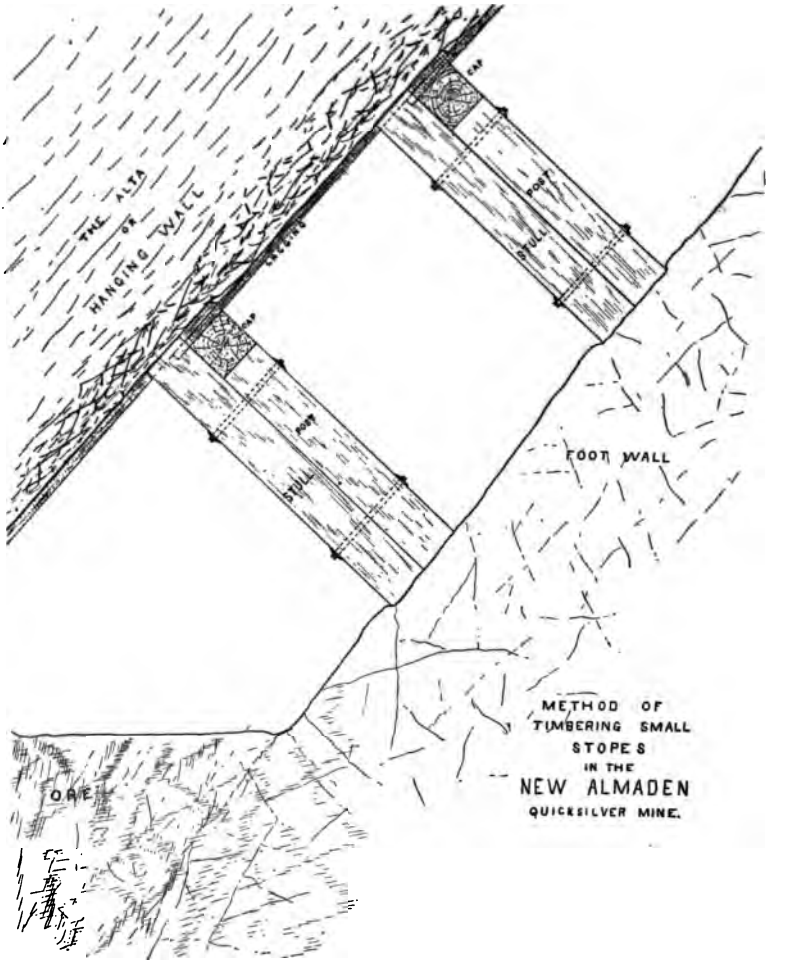
The cuttings in mines which require the most care and greatest skill in placing timbers to support overhanging ground are "stopes" and large "chambers." The method adopted must always depend upon the size of the excavation, character of the ore and of the walls, the pitch of the vein or ore shoot, and also on the expense of the timber.

TAKING ANGLES AND DISTANCE BETWEEN WALLS.

A very convenient instrument for measuring the distance between the hanging and foot walls of the vein, and to determine their respective angles of inclination, for the purpose of cutting stulls with proper length and bevels, is shown in the accompanying illustration. It consists of two flat planed boards having slots, as shown in the drawing, and fitted with thumb screws, s s s. At either end is a movable arm, A A. These are placed against the walls and the screws tightened, the distance between walls being ascertained by lengthening or shortening the instrument by means of the sliding arrangement. Having carefully taken the required measurements, there can be no mistake as to the kind of stull required.

TIMBERING A SOFT HANGING WALL.

In some portions of the New Almaden Quicksilver Mine, where the width of ore stoped is about 10 feet, an unusual method of timbering has been adopted. The foot wall is usually hard and solid, while the "alta," as the hanging wall is called, is almost always soft and shelly, and is considered dangerous ground. Heavy stulls are placed at regular distances (about 8 feet), and are set in line one above another. Im-



mediately above the stull a second shorter timber is laid, which rests upon the foot wall and reaches within about a foot of the hanging wall. A plate or cap is inserted over the upper end of this auxiliary stull, which reaches horizontally across to the next stulls, which are similarly placed. Heavy lagging is driven upward along the hanging wall, the lower ends of which rest upon the cap and the upper ends upon the lower ends of the lagging of the next set above. The two stulls are bolted together near the top and bottom for additional strength and security. Redwood has been used quite extensively in timbering this mine, and it is claimed it has given satisfaction. The accompanying sketch will show this method of timbering. The large stopes of the New Almaden are timbered in square sets.

FLAT OR BLANKET VEINS.

In veins which lie quite flat, the thickness of the vein and the system *must* determine the character of timbering to a great extent, ie character of the walls. Where the vein is thin (a foot or

two) very little timber is required, the waste rock filling the entire space behind the miner. Where the mineral deposit is thicker and timber is necessary various methods are pursued. Some ground stands well by simply leaving pillars of mineral. In other cases a series of upright posts and breasting caps will sustain the roof, the posts being placed in rows directly back of the workmen and as close to the face as the necessity demands. The foot of the post rests either directly on the rock floor or upon a block of wood or piece of heavy plank. The posts are forced into position by driving them up with heavy hammers. Care must be taken that these posts are so placed as to receive the weight of the roof directly and not at an angle. These timbers are set in lines standing in two, three, or four rows back from the face, the waste being piled behind as the work advances. In this manner, by exercising care, many sticks can be recovered before the weight settles so heavily on the refuse rock as to render it impossible to remove the timbers. Some flat veins make little or no waste. It is then necessary to follow the "pillar and stall" system of extraction, considerable blocks being left to sustain the roof. Posts and caps are used in this system also. Frequently the caps reach in a continuous line from post to post, joining the next set, the ends of two caps resting on a single post, the combined sets being a hundred feet or more in width. Large timbers thus placed will support great weight, but if small rocks fall from the roof lagging must also be employed. This system is much in use in California gravel drift mines.

When a vein lying nearly, or quite horizontal, and making no waste, is to be mined, a drift should be run along the lowest portion of the deposit, this point having been reached by incline or shaft. The work advances toward the surface, good sized pillars being left to sustain the roof. If timber is necessary, it is put in place in the manner required. The work having advanced sufficiently far toward the surface, the pillars may now be cut out at the back end, while the work progresses as before. As the pillars are removed more timber must be put in, or waste from the surface must be piled in cribs of timber built in the workings already made. Usually some timber can be recovered in this way and the caving of the roof after the complete removal of the ore, or mineral, does no harm. The main gangways should be substantially timbered, if necessary, as it is desirable to keep it open to the lowest working level at all times.

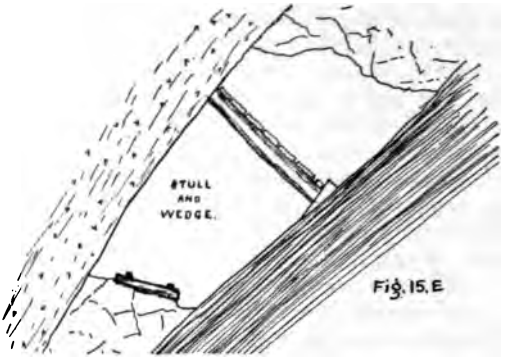
The "long wall" system of extracting ore is usually carried from the surface inward, a main gangway having been first driven ahead to a connection with a ventilating shaft, when possible. All the ore is removed at once, the waste being thrown back of the miners, who carry the breast forward with the center considerably in advance of the sides, the excavation being in form somewhat like the letter "A," with the apex forward. The waste is thrown into the center to support the roof, while the side passages permit of a free circulation of air all along the face.

STEEPLY INCLINED VEINS.

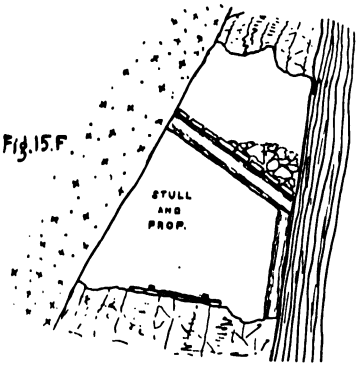
In vertical or steeply inclined veins, the principles governing the methods of timbering are essentially the same as those above explained, though the application is different. In such workings the post of the flat vein becomes a "stull."

OVERHAND STOPING.

When a working drift is driven along a vein in ore and it is the intention to "stope" out the ore, the character of the walls and the width of the vein or deposit must determine the method of timbering. If the walls be hard and firm, and the vein not more than 10 or 12 feet



wide, posts are not absolutely necessary. Stulls of the proper length are placed with the lower end resting on the foot wall, or in a niche cut for the purpose, the upper end being placed against the hanging wall and driven downward until it stands at a few degrees above a right angle with that wall. (See Figs. 16 and 18.) When the foot wall has a greater inclination than the hanging wall, a support resting on the floor of the drift must be placed under the lower end of the stull. Should the foot wall have a less inclination than the hanging wall, the foot of the stull may be secured by driving in stout wedges from the upper side. Where the foot wall is sufficiently hard and firm, a niche in either case will answer as a secure rest for the lower end of the stull. Where the vein is more than 10 feet in width and additional support appears necessary, resort may be had to the plans shown in Figs. 19 to 29.



In case either wall, or both of them, is too soft to safely sustain stulls under the pressure of ore or waste to be piled upon them, a plate (usually a 2 or 3-inch plank) is inserted behind the stull on either wall or both, as may be necessary. (Figs. 17 and 25.)

When the walls are very soft, and even with the use of plates, render timbering insecure, the stulls may be placed at right angles to the walls, the ends resting upon posts. Mining upward, the posts of each floor rest upon the stulls under foot and immediately above the posts on the floor below. In this manner a stope in soft walls may be carried to any desired height. (Fig. 24 A.) In such instances it is necessary to use *longitudinal* braces or "ties" reaching from cap to cap at

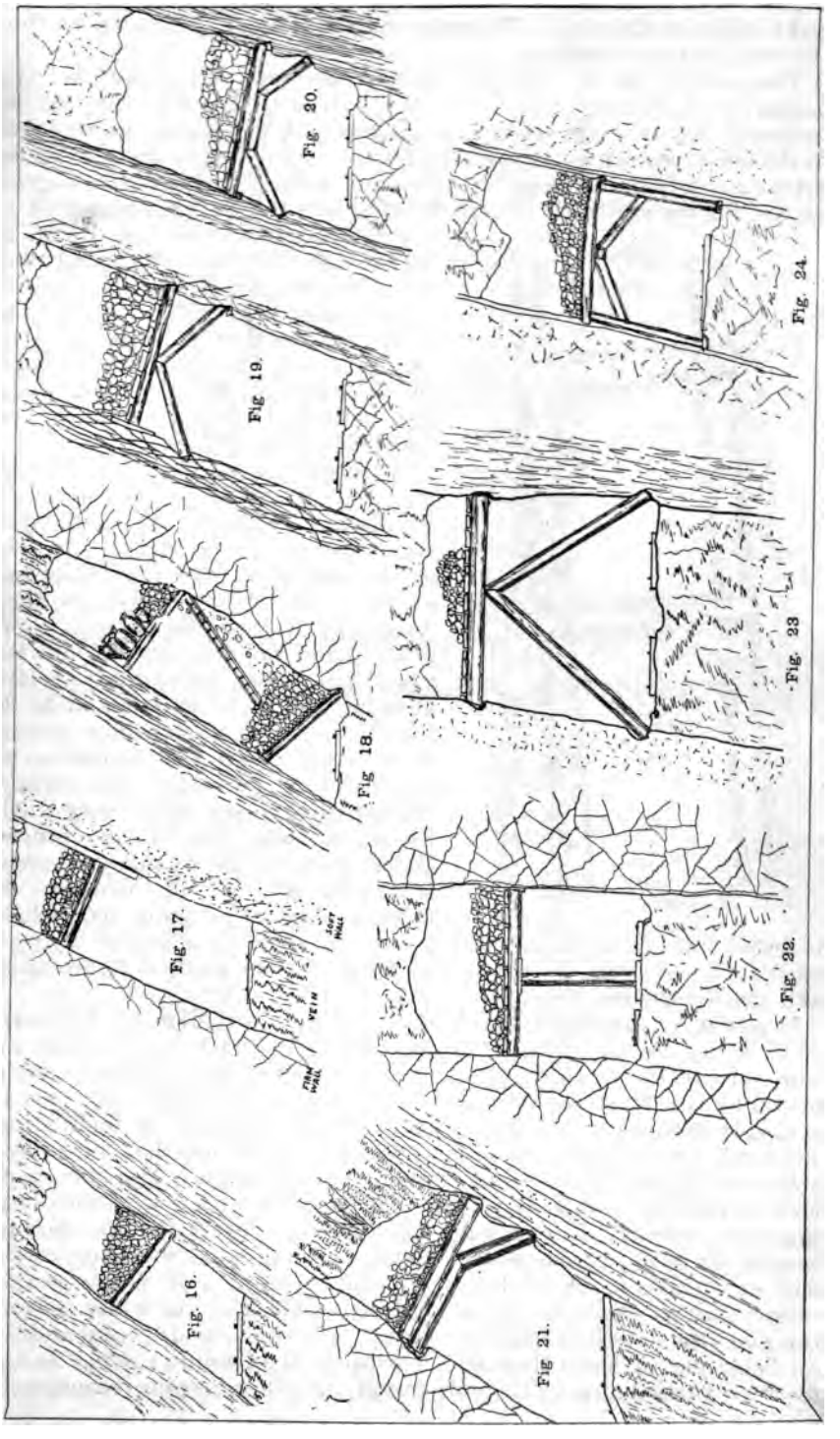
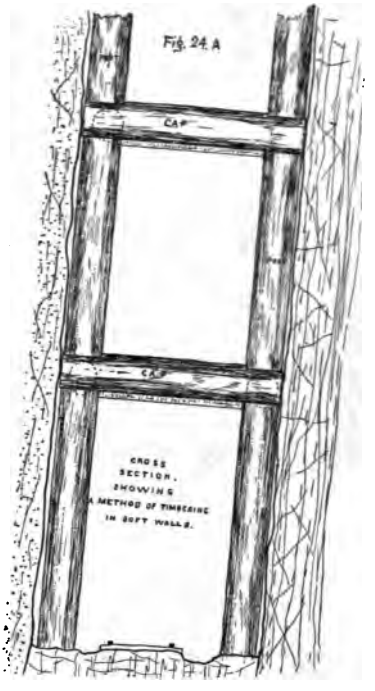


Fig. 16.
Fig. 17.
Fig 18.
Fig. 19.
Fig. 20.
Fig 21.
Fig. 22.
Fig. 23
Fig. 24.

right angles to the stull. These ties may be of smaller dimensions than the stull and post timbers.

The method shown in Fig. 19 may be employed where the vein exceeds 8 or 10 feet and when sticks sufficiently large to support the weight of ore or waste cannot be obtained. Fig. 20 may be employed in the same manner with a greater width of vein. Both of these instances presume considerable waste to result from mining, which will, to a great extent, fill the excavation. Fig. 23 affords a firm support to a stull in a wide place in the vein, and Fig. 22 the same in a still broader vertical vein. Fig. 25 shows how, in a vein of low dip and considerable width, a stull may be firmly supported to retain waste or ore coming down from the stope above. In soft vein and wall rock a substantial method of placing sill, stull, and post is shown in Fig. 26.



Stulls are placed at distances ranging from 2½ to 6 feet, as may be required. On them are laid split lagging, forming a floor. As the miner stands on the floor thus improvised, he breaks down the ore, separating it from the waste, if there be any, and sending the ore into the "level" or main passageway below, allowing the waste to accumulate on the floor. The waste often occurs to such an extent that a portion of it also has to be sent to the surface. When this is the case, very little timber is required in the stopes. When, however, the quantity of waste is small, it is often necessary to build a temporary staging upon which to stand until a sufficient space is cut out above to admit of laying a second tier of stulls to sustain the floor. Floors are 6 to 8 feet apart and sometimes even more.

A passageway, called a "mill hole," "chute," or "slide," is left every 30 to 50 feet for the purpose of sending ore to the level below, as the work progresses upward. The distance between these slides is determined by the dip of the vein. They may be a greater distance apart in a steeply inclined vein than in one having a low angle of inclination. Rock will not run freely on a slope having a slope of less than 40 degrees, and more is preferable. In cases where the slope angle is low, it is a good idea to line the slide with plank to facilitate the delivery of the ore to the level beneath. In opening a stope between levels, the best method is to make a raise from level to level, building a loading chute at the bottom. Then at a short distance to one side (15 or 20 feet) a second raise is carried up about 15 feet and connected with the winze. From this point the stope is opened, the excavation being carried upward and the ore being passed down through the winze to the loading chute. As the ·rs are carried up a crib is built around the winze, keeping it constantly

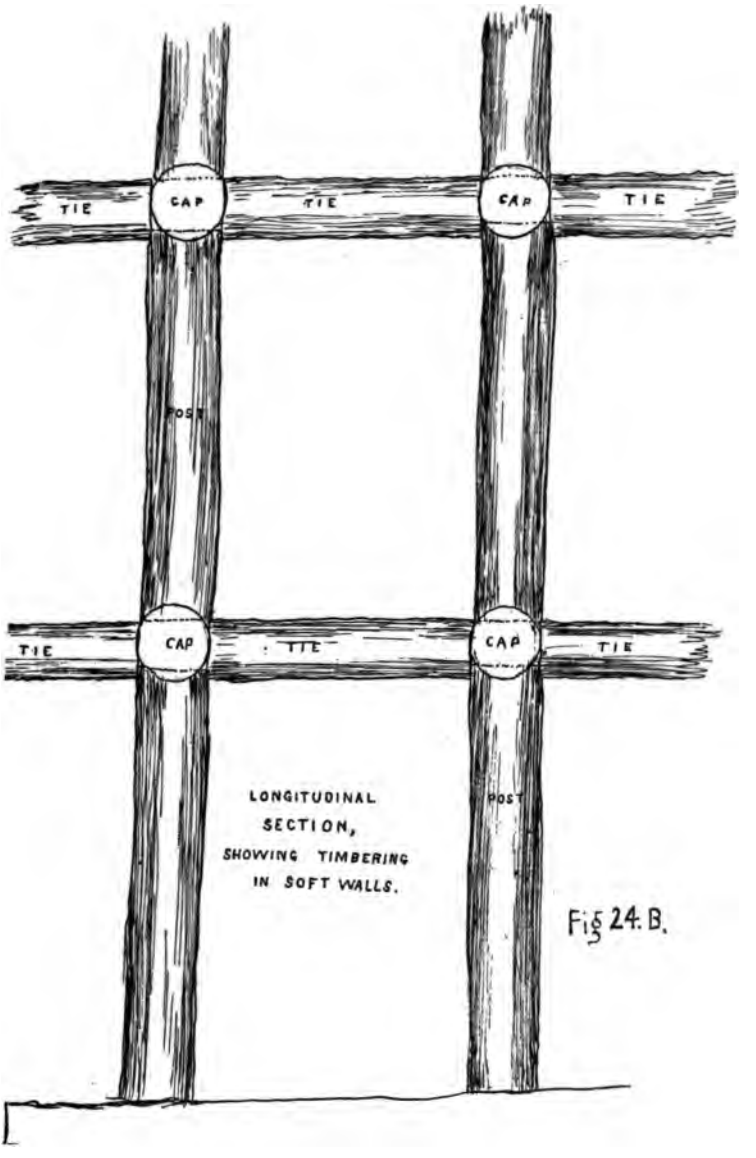


Fig 24. B.

open. This plan secures economy of labor and affords the best obtainable ventilation. The stoping of ore continues to within a few feet of the level above, and is then discontinued for the time being, this mass of ore and that remaining within a few feet of the floor beneath being left to be taken out the last thing before abandoning this portion of the mine.

When ore is very rich it is the custom to blast or pick it down upon canvas or boards, keeping it separate as far as possible from the waste, the ore being sacked in the mine. The methods above described apply to overhand stoping, that is, excavating from a level upward.

UNDERHAND STOPING

Is the term used to indicate an operation the reverse of that just described, being the method by which the miner takes out the floor of his level and continues the excavation downward in a series of steps 7 or 8 feet in height. In this method it is best for the economical handling of the ore, for ventilation, and for drainage, to have established a connection by winze with the level next below, or it will be necessary to hoist all the ore and water from the stope to the level above. The waste, if there be any, is thrown on platforms or floors between the face of each floor and the winze, slide,* or chute. This method is not advisable except in narrow, rich veins.

Underhand stoping is not commonly followed, but may be recommended in working small veins of very rich ore. It requires usually more timber than overhand stoping and the timber cannot be recovered as in the latter method.

CONNECTING LEVELS.

When stoping by the overhand system, on approaching the floor of the level above it is necessary, where posts and caps have been used, whether sills were used or not, to take some precaution to prevent the falling out of these timbers and the consequent caving of the filled stope above, should there be any. The plan adopted in the Bi-metallic Mine, near Phillipsburgh, Montana, is the most expeditious and the safest. When ready to break through the floor under any particular sill or set of timbers, a stout piece of timber (sprag) is placed between the posts a few inches above the floor (at A) and wedged in hard with shingle wedges. A heavy stick of timber (B B) long enough to reach across three sets (kept on each level of the mine for this purpose) is lifted to the roof of the gangway, midway between the posts, one end being under the cap which forms a portion of the set of which the sill to be removed is also a part. This timber acts like a lever having a fulcrum at C, in the form of a post which supports it, the foot resting in the center of the drift on the sill D. Wedges are driven in at E, making it firm and rigid. Wedges are then driven in at F and at C, and the rock beneath may then safely be extracted, the timber-set G G being held in position, the superincumbent weight being transferred to the points D and E. As a matter of course, the sill of the set G G will drop out when the rock upon which it has rested has been removed. The remainder of the set may then be connected with the timbers of the sets beneath in any manner the case requires.

STRENGTH OF TIMBERS.

In placing stulls to sustain the weight of waste, or to store ore already broken, the size and number of timbers to be employed must be determined by the width of the vein and the height to which the waste or ore is likely to accumulate. It is considered better to increase the number rather than the size of stulls. With good walls, stulls 7 feet in length, having a thickness of 12 inches, placed 30 inches apart, are calculated

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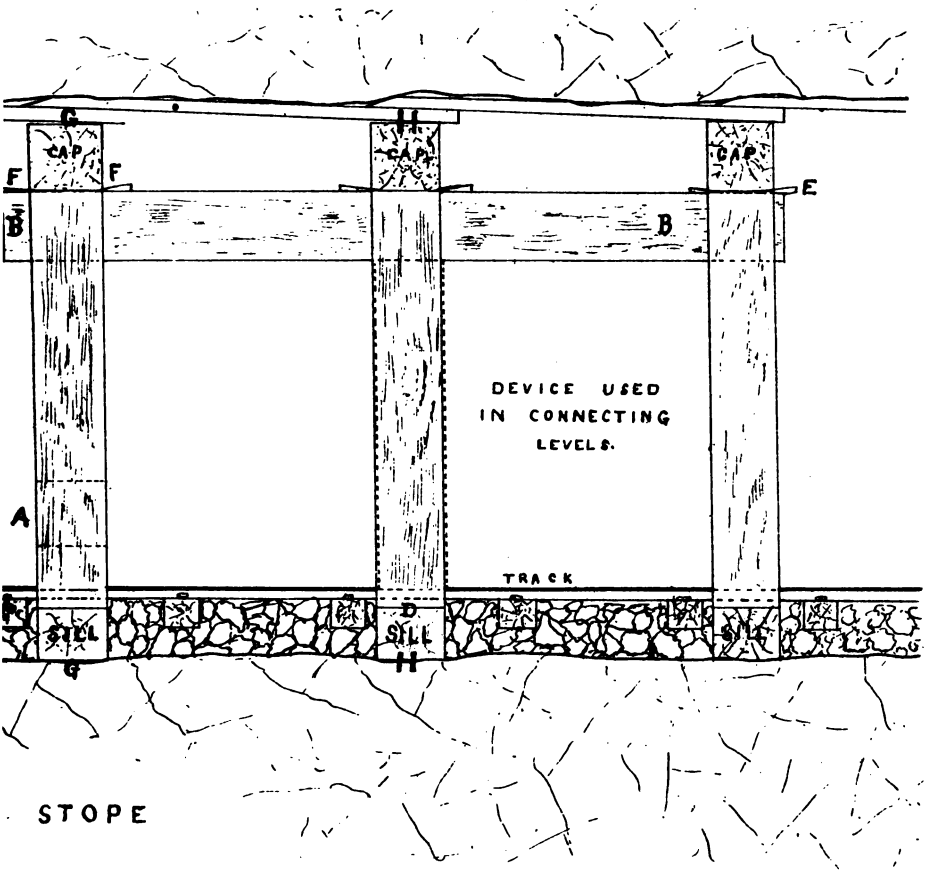
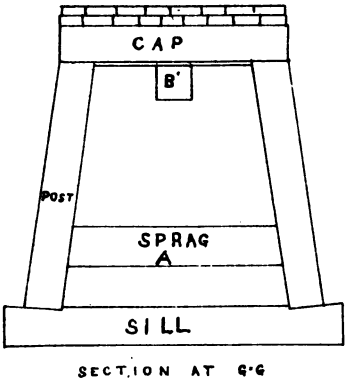
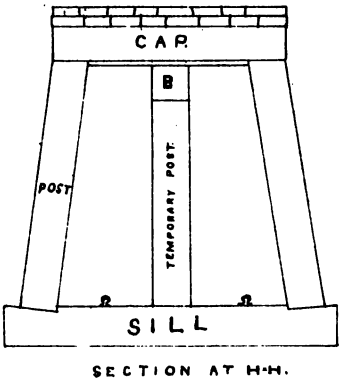
*The term "ore slide" appears preferable to the word "chute," as conflict is thereby avoided with the word "ore shoot" as applied to a body of ore.





SECTION AT G·G



SECTION AT H·H.

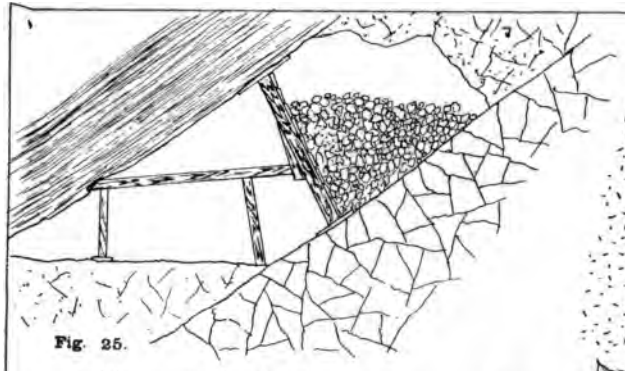


Fig. 25.

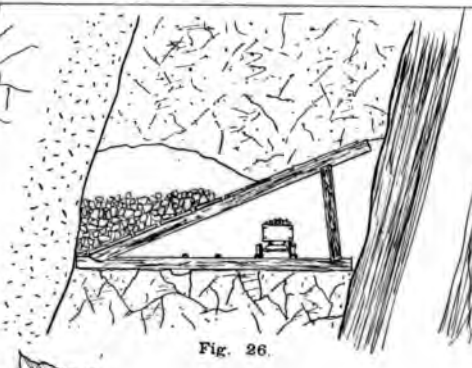


Fig. 26.

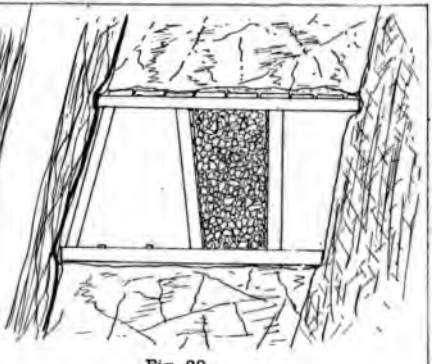
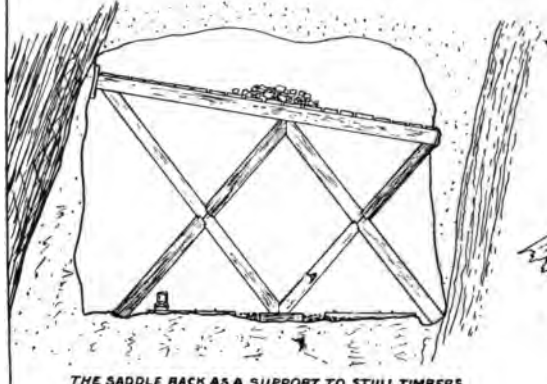
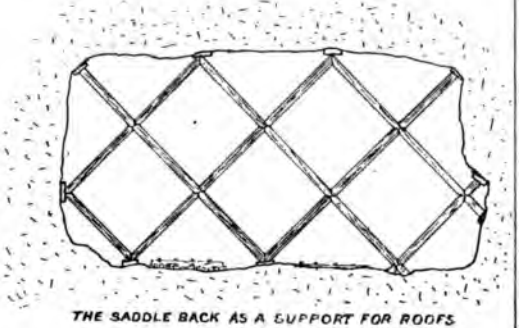


Fig. 29.



THE SADDLE BACK AS A SUPPORT TO STULL TIMBERS AND WASTE IN A STOPE OF A LARGE VEIN

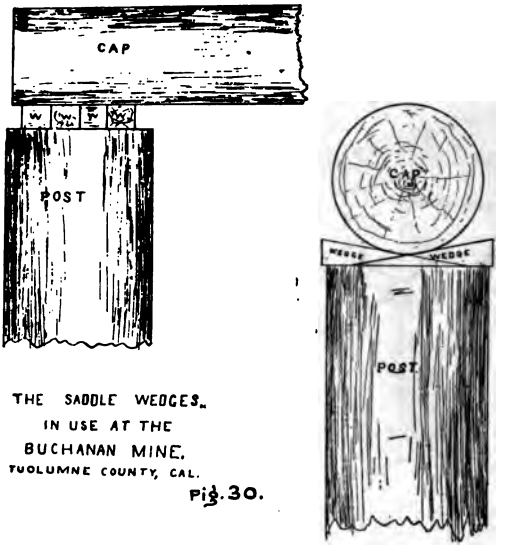
THE JOINT IN THE SADDLE BACK



THE SADDLE BACK AS A SUPPORT FOR ROOFS

to sustain 60 feet of waste or broken ore in a vein standing at a high angle. After waste has remained in place for some time it settles, and in some instances becomes so firm as to retain its solidity after the stulls have fallen out or have been removed. This need not be expected in wide veins.

When it becomes necessary to quickly catch up settling stull timbers or caps, a stout post, which will just slip under the sinking timber, is placed in position and four stout wooden wedges, having the inclined planes sloping alternately in different directions, are driven in between the post and stull. This plan will recover the subsidence, if not too great, and permit of reinforcing the timbers without losing ground.



THE SADDLE WEDGES IN USE AT THE BUCHANAN MINE, TUOLUMNE COUNTY, CAL.

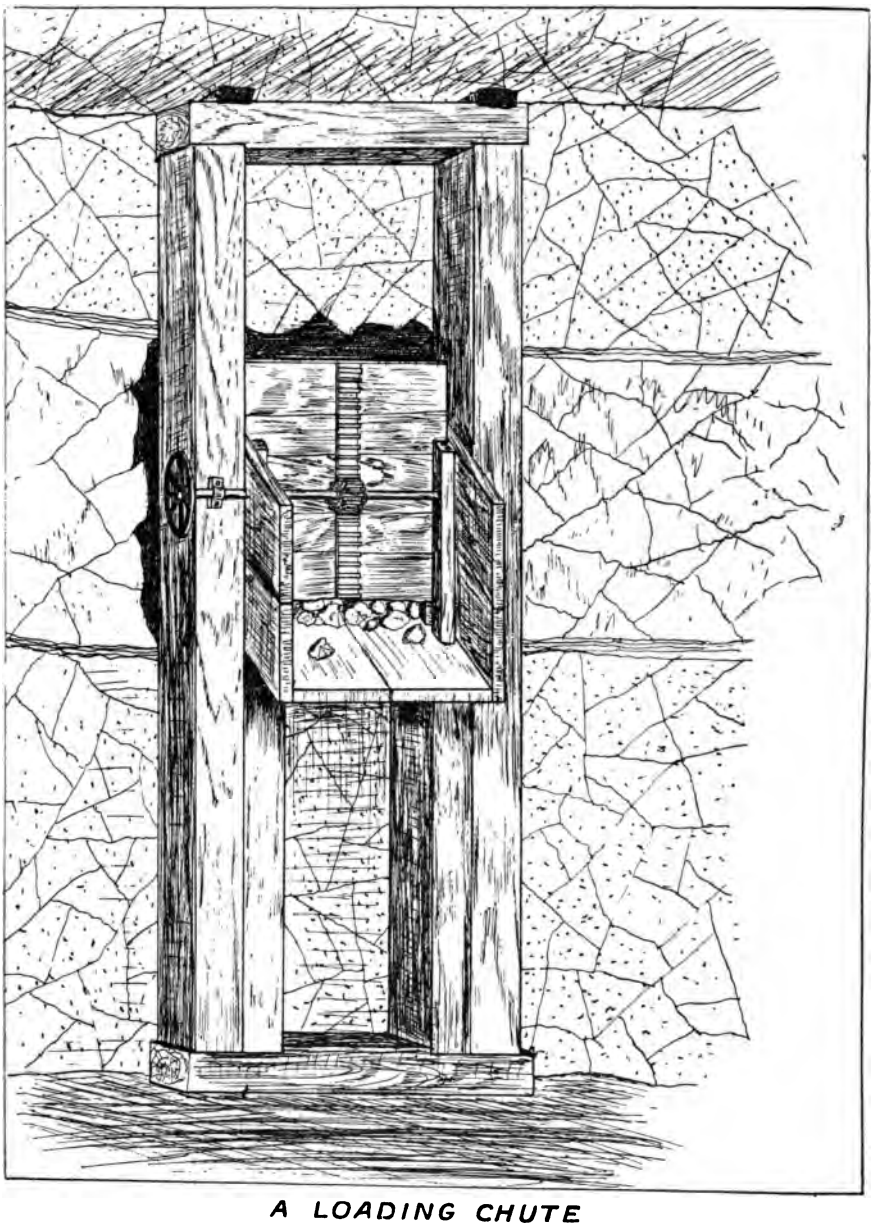
Fig. 30.

SADDLE BACKS.

A peculiar method of timbering, known as the "saddle back," is in vogue in some portions of Colorado. It appears to do well in the lead-silver mines having good limestone roofs and walls. It may be considered a modification of the "square-set." It requires less timber and is far less substantial. It will not do in heavy ground. The details differ with the various conditions encountered, but the principles are those obtaining in all other timber systems—the application of resistance to pressure. The drawings illustrate one method of setting up the saddle back.

LOADING CHUTES.

The accompanying sketch shows a design for a loading chute or slide, though they are not always made as elaborate as represented in the drawing. The inclination of the bottom should exceed 30 degrees, ores that are soft and wet requiring the slide to have a greater pitch than those that are dry. Between the two upright posts which reach from *the floor of the* drift to the roof or to stout stulls overhead, two short



A LOADING CHUTE

Fig. 31.

uprights are placed, and on top of them, reaching from one to the other, is laid a 4x6 scantling. The gate, furnished with ratchet and wheel and pinion, may be dispensed with, loose boards being substituted, which may be pried up, when desired, with a bar. It is well always to build *loading chutes in a* substantial manner, so that rebuilding may not be

necessary. It is a wise plan to provide false sides and bottoms, which may be quickly renewed.

The posts supporting loading chutes are not always placed perpendicular. In steeply inclined veins it is sometimes desirable to set them inclining forward. In vertical veins they are built across the vein.

In square sets, ore bins are constructed within the sets and the chutes are attached to the caps or ties, being arranged at convenient distances from each other.

In some mines, as in the Golden Gate, at Sonora, in Tuolumne County, large storage bins are constructed below the floors of the levels at the hoisting shaft, provided with a loading chute. The skip is stopped at the proper point and loaded. In this manner the necessity of waiting for cars, or loaded cars and men waiting for the skip, is obviated. In this mine loading chutes are provided on the several levels from the stopes overhead, as a matter of course being constructed in the ordinary manner.

GREAT CHAMBERS AND SQUARE SETS.

The systems of timbering hereinbefore described refer particularly to veins having a width not exceeding 12 feet, though mines have been worked under great difficulties, and where the operations were attended with extreme danger, where the distance between walls was 20 and even 25 feet. An instance may be mentioned in California in the Mount Jefferson Mine, at Groveland, in Tuolumne County, where the vein was 25 feet from wall to wall. A very ingenious system of timbering was introduced in 1854, or thereabouts, consisting of long stulls supported by wall and inside props 7 feet apart. Longitudinal braces, or ties, were also introduced to support the timbers longitudinally, but the support was insufficient, and a most disastrous case resulted. It is a matter of absolute impossibility, however, to recover, by the methods thus far given, all the ore from such great masses of mineral as were found in the Comstock Lode, where one ore body, the Great Bonanza, measured 340 feet in width at one point, 600 feet in height, and 1,250 feet in length. Stopes in the various mines of the Homestake group, in the Black Hills, South Dakota, range from 40 to 150 feet in width and several hundred feet in length and height. The Caledonia Mine, of this group, measured on the 300-foot level 195 feet horizontally. The Homestake vein at the surface, in the open cut, is 360 feet wide, by actual measurement.

In California there are many mines of great value that cannot be worked by any system of stulls. The Stonewall Mine, in San Diego County, has 20 feet or more of vein in places. The Alvord Gold Mine, in San Bernardino County, is a very wide vein. The Odessa, Occidental, Oriental, Silver Monument, and Waterloo Mines, of the Calico District, measure 30 to over 100 feet in width. Some of the mines of Bodie have very broad veins. The Josephine Mine, in Mariposa County, has an immense ore shoot 50 feet wide. The Utica-Stickles Mine, at Angels, Calaveras County, is 40 to over 100 feet wide, and the Gover Mine, of Amador, has an ore body 30 to 50 feet wide. The Zeila, at Jackson, is working an immense mass of ore. The Boston Mine, near Mokelumne Hill, is 40 to 60 feet wide, and some of the ore bodies in the larger quicksilver mines are of prodigious size. In addition to these there are many *other mines on the* gold belt of California where the great width of vein

precludes the extraction of the ore by the use of any system of stulls or simple posts and caps.

Veins and ore bodies of large size can be safely, completely, and cheaply mined by using what is known as the "square set" system of timbering, introduced in 1860, by Philip Deidesheimer, while Superintendent of the Ophir Mine, on the Comstock Lode.

INVENTION OF SQUARE SETS.

The following interesting reference to early mining on the Comstock is from Monograph IV, of the United States Geological Survey, "Comstock Mining and Miners."

"At the 50-foot level (of the Ophir Mine) the vein of black sulphurets was only 3 or 4 feet thick, and could readily be extracted through a drift along its line, propping up the walls and roof, when necessary, by simple uprights and caps. As the ledge descended the sulphuret vein grew broader, until at a depth of 175 feet it was 65 feet in width, and the miners were at a loss how to proceed, for the ore was so soft and crumbling that pillars could not be left to support the roof. They spliced timber together to hold up the caving ground, but these jointed props were too weak and illy supported to withstand the pressure upon them, and were constantly broken and thrown out of place. The dilemma was a curious one. Surrounded by riches they were unable to carry them off.

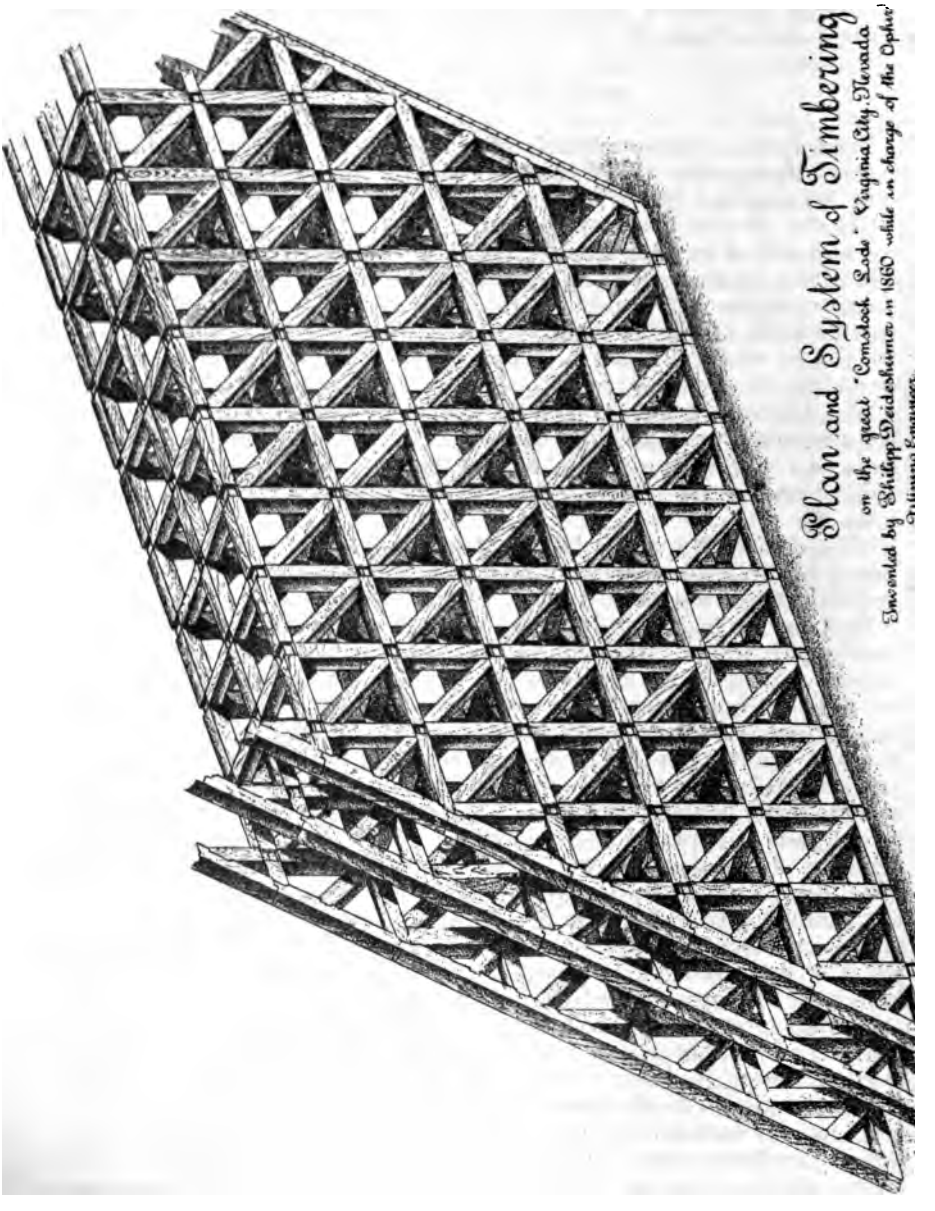
"The company was at a loss what to do, but finally secured the services of Philip Deidesheimer, of Georgetown, California, who visited and inspected the treasure-lined stopes of the Ophir."

That the ore body could not be extracted in the usual manner was at once apparent, and Mr. Deidesheimer says he set about his task with some misgivings. He did not at one stride grasp the idea of the square set, but the system which now bears his name was the outgrowth of circumstances and the very necessities of the case. He instituted a policy, however, the wisdom of which soon became apparent.

The first step was to cross-cut the vein from wall to wall, starting from a drift on the hanging wall side of the vein. As the work advanced he set up posts and placed caps above them, not across the course of the drift, as is usually done, but along the sides, the idea being to form, when completed, a line of caps which would reach continuously from wall to wall. To accomplish this the ends of two caps were placed upon each post, except at the ends. These novel sets were held in place by pieces of 2x4 scantling 4½ feet in length and reaching across the drift from near the top of a post to that opposite.

Having successfully driven the cross-cut, Mr. Deidesheimer now ran a drift some distance along the foot wall, timbering with posts and caps in the ordinary manner; that is, the caps were placed upon the posts at right angles to the drift and parallel with those in the cross-cut. The posts in each case were set perpendicular. Returning to the point where these operations were begun, a second section by the side of the first cross-cut was taken out and timbered with a single line of posts and caps, the 2x4 scantling being placed as in the first case. When this section was completed there were standing three lines of posts surmounted by three lines of caps, extending from the foot to the hanging wall. This *was not really* a new idea, as Mr. Deidesheimer had previously

employed the same method in his drift mine on Forest Hill, when the breast was carried in 125 feet wide, the roof being supported by rows of posts with continuous caps.



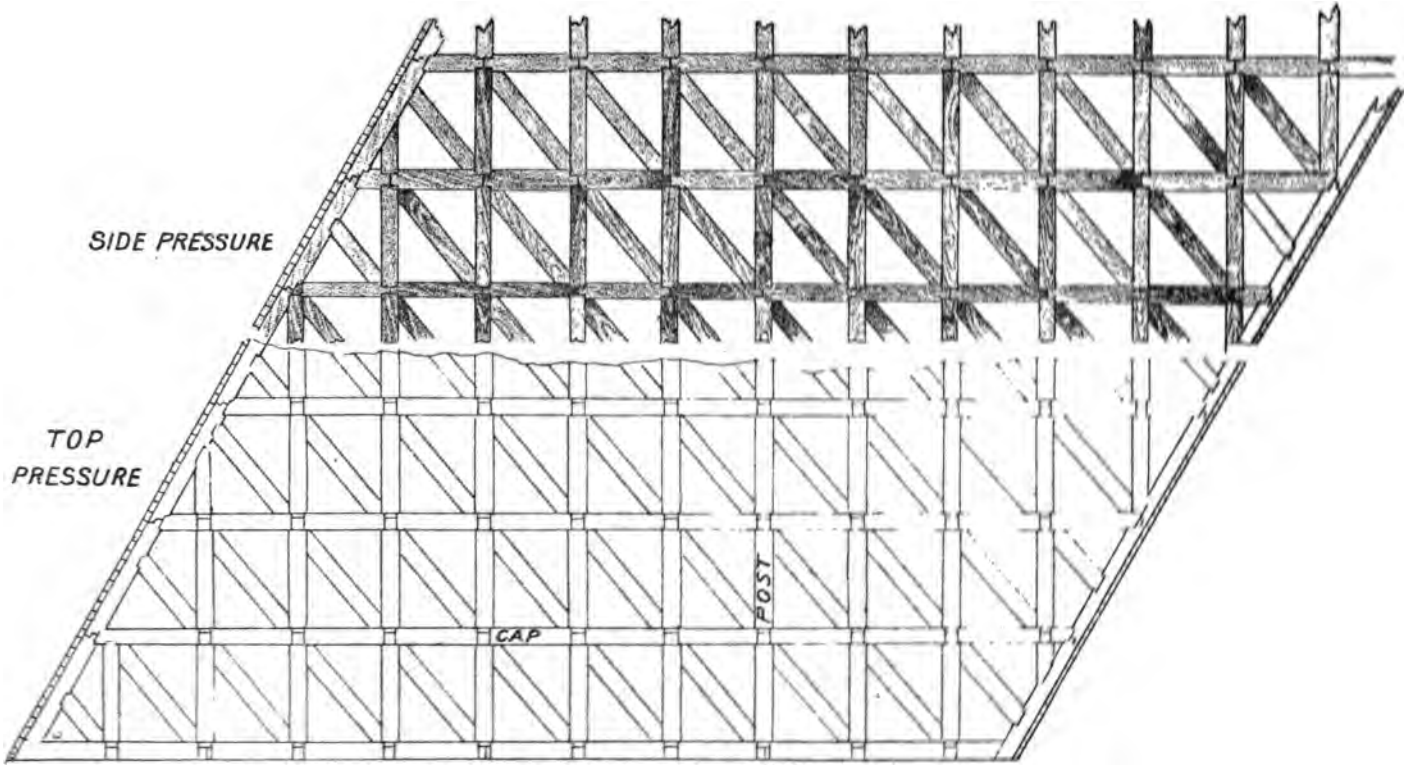


Fig. 33.

The work thus far performed in the Ophir revealed the fact that an extremely rich body of ore extended upward from the level where this work had been done. The miners were directed to commence stoping upward in the body of soft, black, crumbling ore, and soon a considerable excavation had been made. It became evident that the ground must be secured at once.

In the Georgetown Mine, that Mr. Deidesheimer had left but a short time before, the vein was vertical, and the walls were so soft and crumbling that in order to stope out the mineral he had resorted to the expedient of setting one post directly above another, the lower end resting on the cap, and in this way he managed to work the vein without much difficulty.

The Georgetown experience suggested the idea of adopting a similar plan in the Ophir. Accordingly, Mr. Deidesheimer had a mortice cut at the junction of two caps, which were already in place, and having a post framed with a tenon to fit, set the post in place directly above the one resting on the floor below. In a short time four posts were in position with the caps upon them as below, together with the frail 2x4 scantling, the office of which was to keep the other timbers from falling down. The first "square set" timbers, it will be seen, were framed in the mine, the mortices being cut in the timbers in place. The work of extracting ore proceeded slowly yet, for the ground had to be secured as well as possible. It soon became evident, however, that something more substantial than 2x4 scantling would be required to keep the timbers in position, and it was determined to put in timbers of the same dimensions as those forming caps and posts. This was done at once, and the "square set" was complete in principle, though not in detail. The caps occupied all the space on top of the posts, leaving no resting place for the "ties," which had to be supported in some other manner. As they were looked upon as simply an auxiliary—a support to the posts and caps—they were only required to be held in position. Accordingly a lot of iron spikes were made, in shape somewhat like the thumb, having a sharp point at one end, the other end having a face three fourths of an inch square. Two of these spikes were driven into a post at the proper height, and two in the post opposite, and the tie placed so that the ends rested upon these iron lugs, wedges being driven in at the ends to secure firmness. The posts and caps were now framed on the surface and delivered below, ready for use wherever needed. The work of mining now progressed much more rapidly and the problem seemed solved. Soon after it was determined to frame the timbers so that the ties might also rest on the posts. The stopes becoming of such great size, the dimensions of the timbers were increased and they were then framed as shown in the accompanying illustrations.

As the work progressed slight changes were made from time to time whenever any improvement seemed possible. Sills were laid upon the floors of the levels as a foundation for the timbers above, which had now assumed massive proportions. The sill timbers were cut as long as it was possible to get into the mine. The men who were obliged to handle these ponderous timbers could see no reason why the sills should be longer than the caps, and from the first looked upon the growth of timber with much prejudice. When the great [illegible] the wisdom of the use of long [illegible] the ore and

the placing of timbers without danger or loss, which could not have been accomplished with short sills, as when breaking up through the floor of a level from below short sills would have nothing to sustain them.

When, in the course of ore extraction, the work reached the walls, additional timbers, called "wall plates," were put in, as shown in the sketch of timbering in the Ophir Mine. The caps were extended from the nearest post to the wall plate, except when a post came within two feet of the wall plate. In such case the cap extended from the wall plate to the second post in a single piece.

By a close inspection of the drawings the details may be plainly seen. It will be noticed that a system of braces reaching diagonally across the sets was also introduced, as well as close lagging on the walls. There is no doubt that the Ophir was the best timbered mine in the world, but the Comstock miners who gladly adopted the Deidesheimer system soon began to disregard many precautions which to them seemed unnecessary. The diagonal braces were left out, and the ground was found to stand about as well. Then, anxious to still further reduce expense and hurry the work of extraction, the lagging on the walls were dispensed with, and later, in somewhat firmer ground, the wall plates were left out, and finally the timbers were placed in rectangular sets, with only a few props here and there to the walls and roof, as shown in the drawing of the Caledonia Gold Mine. The disregard of these important details in American mines has resulted in numerous disastrous caves.

Owing to the careless timbering in the "Big Bonanza," in the California and Con. Virginia Mines, cribs of solid timber had to be built, reaching from the floor to the roof.

The sketch of the Caledonia Mine, in the Black Hills, S. D., represents the mine as it appeared in the spring of 1883. The main shaft was sunk in the large vein, the hoisting works being located on the adit level, 200 feet from the surface, vertical measurement, and 820 feet from the mouth of the tunnel. This shaft reached the foot wall on the 300-foot level, and a large stope was at once opened around the shaft, a pillar of ore 30 feet square being left to support it. The shaft was continued vertically to the 400-foot level and an extensive stope opened there also. The gold-bearing rock of the Caledonia is hard white quartz, which occurs in bunches and reticulated veins in chloritic schist, and in this respect resembles some California mines, as the Utica-Stickles, Gover, and some others. In the Caledonia great headers were excavated in advance of placing the square sets. The timbers were all properly framed and were massive, but there was a disregard of what were considered the minor unnecessary details in placing them, particularly on the walls and against the roof. As these large stopes were extended, too broad an area was taken out at one time, and the superincumbent weight at length threw the timbers out of line, and almost without warning the mine caved, the immense timbers "jack-knifing" and snapping like reeds. Thousands of tons of ore, the expensive machinery, and a mass of splintered timbers were dumped in a chaotic mass to the bottom of the 400-foot level. There were three causes which led up to this disaster: The extraction at one time of too large an area of ground; carelessness in timbering, and the slippery nature of the foot wall (talc schist), which afforded a poor support to the large pillar of ore.

It is unreasonable to expect a frame of timbers, however strong, to support the weight of a mountain of rock, and for that reason discretion

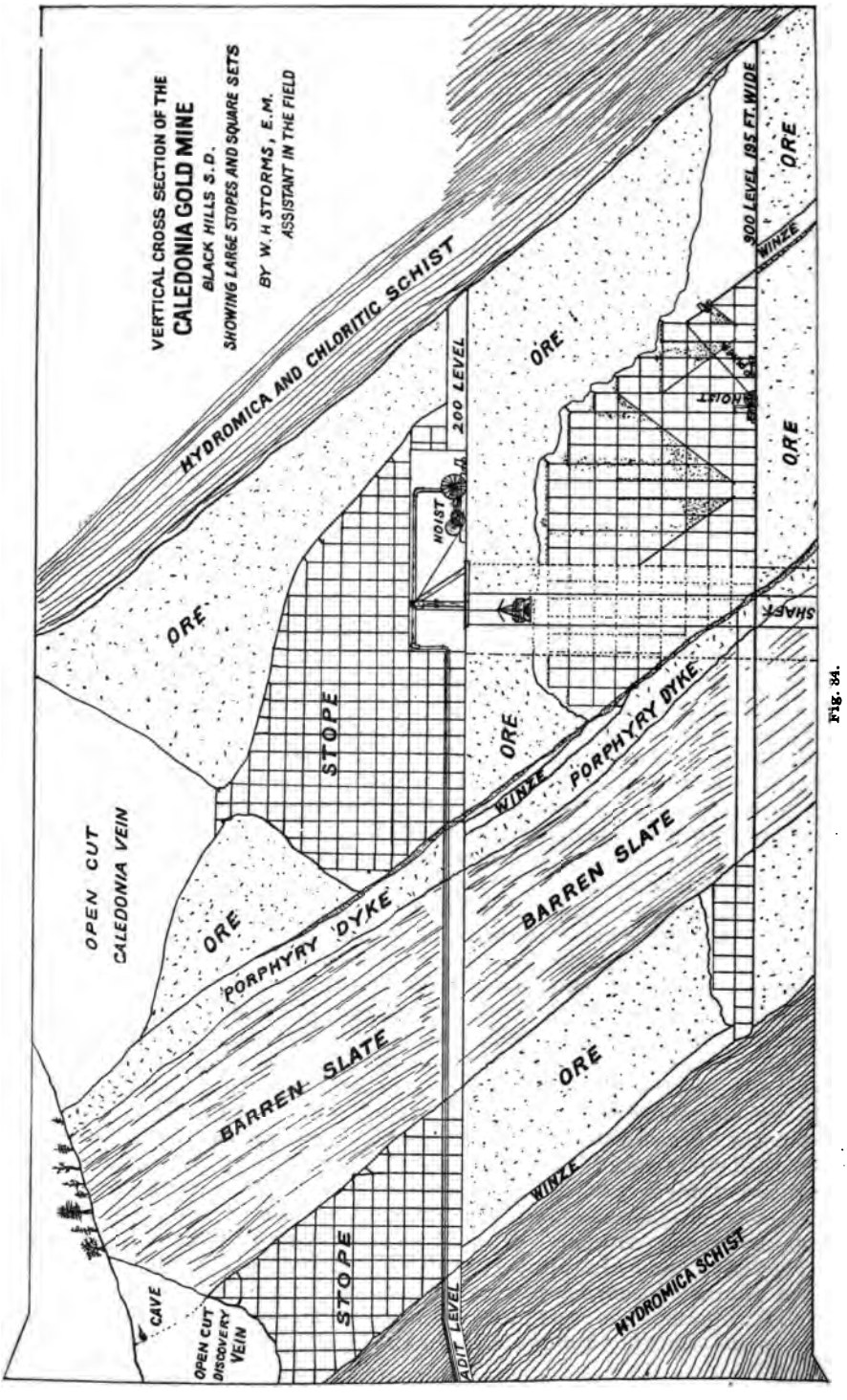

VERTICAL CROSS SECTION OF THE
CALEDONIA GOLD MINE
BLACK HILLS S.D.
SHOWING LARGE STOPES AND SQUARE SETS
BY W. H STORMS, E.M.
ASSISTANT IN THE FIELD
HYDROMICA AND CHLORITIC SCHIST
ORE
STOPE
200 LEVEL
HOIST
ORE
300 LEVEL 195 FT. WIDE
ORE
WINZE
HOIST
SHAFT
ORE
PORPHYRY DYKE
WINZE
BARREN SLATE
OPEN CUT
CALEDONIA VEIN
ORE
PORPHYRY DYKE
BARREN SLATE
ORE
WINZE
CAVE
OPEN CUT
DISCOVERY
VEIN
STOPE
ADIT LEVEL
HYDROMICA SCHIST

Fig. 34.

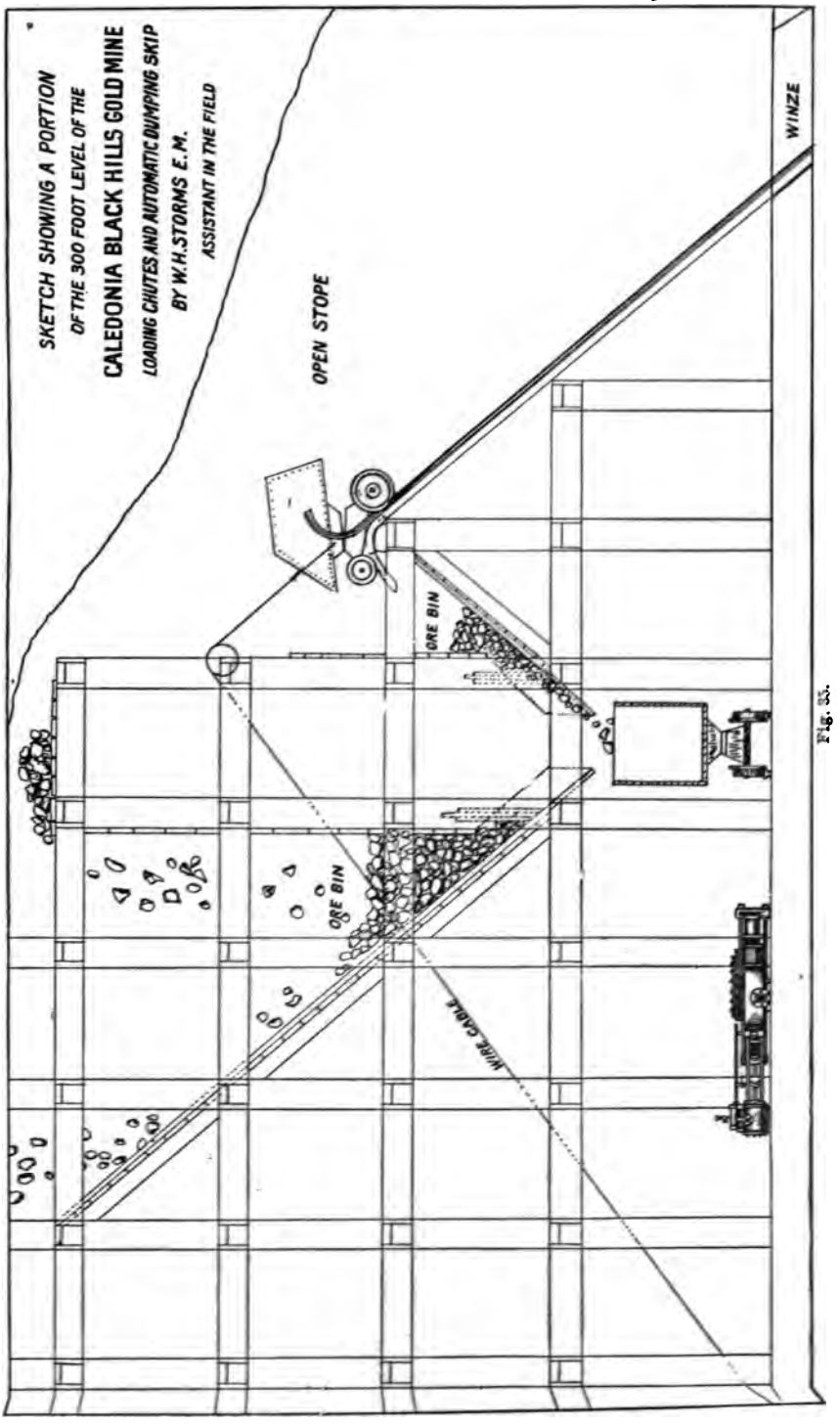

SKETCH SHOWING A PORTION
OF THE 300 FOOT LEVEL OF THE
CALEDONIA BLACK HILLS GOLD MINE
LOADING CHUTES AND AUTOMATIC DUMPING SKIP
BY W.H.STORMS E.M.
ASSISTANT IN THE FIELD
OPEN STOPE
WINZE
ORE BIN
ORE BIN
HOIST CABLE

Fig. 33.

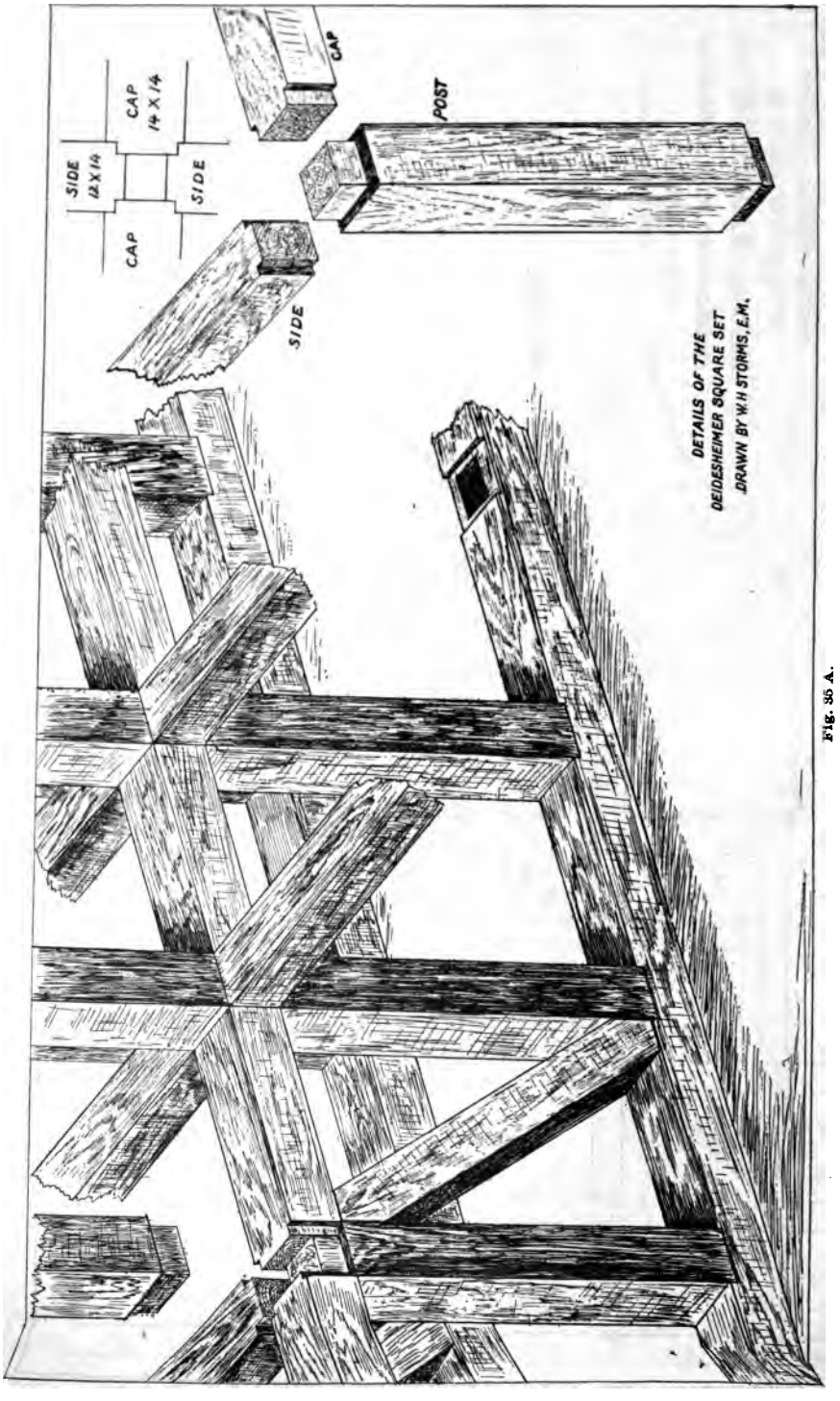

SIDE
4 X 14
CAP
14 X 14
SIDE
CAP
SIDE
CAP
POST
DETAILS OF THE
DEIDESHEIMER SQUARE SET
DRAWN BY W.H STORMS, E.M.

Fig. 35 A.

should be used in extracting large bodies of ore. It is hazardous to attempt to remove a section more than three or four sets wide at one time from the floor of one level to that next above. A breast may extend entirely across the deposit or vein, but if more than four sets in width are removed at one time it allows too much weight to fall upon the timbers, and the probability of a cave is greatly increased.

By taking out a section, which may extend entirely across the vein or deposit, three or four sets wide, and carrying the stope up somewhat in the form of a pyramid, so that on nearing the floor next above only the space of a single set, or at most, not more than two, be at first removed, and the timbers firmly wedged to the sills before enlarging the excavation at that point, all the ore may be extracted, and the operation in this manner is attended by the least expense and danger. When a section has been mined out from level to level as described, a second section may be attempted. Under all ordinary circumstances it will be found that the timbers will usually support the ground until the stopes can be filled with waste. At many mines waste is obtained on the surface, and in some the opening of large chambers in the hanging wall is necessary to obtain a sufficient amount of material for filling the stopes. There is always danger in the removal of a mass of rock which stands on a base that is broader than its upper portion, or apex, like the letter "A," while on the other hand a "V" shaped mass is largely supported by the walls. Many ore bodies are lens-shaped; that is, broader at the center than those portions either above or below; and in these masses the greatest expense and danger attend the removal of the upper portion.

CONSTRUCTION OF SQUARE SETS.

In building square sets, the sills, 16 to 20 feet in length, are first laid down on the floor at right angles to the walls. These timbers are the largest in use in the mine, and should properly be as long as they can be handled. At regular intervals shallow depressions are cut across the upper face of the timber one inch in depth and superficially the same size as the posts which are to rest upon the sill. In the center is cut a mortice, two thirds the square of the post, at least 6x6, and larger as the size of the timber is increased. Into the mortice, a tenon on the bottom of the post fits nicely. The sills are laid horizontally and exactly parallel, at such distances as may have been determined upon, usually 5 or 6 feet from center to center of the posts. The sets may be placed in the form of squares or rectangles. Two sills having been laid, four posts, constituting the four corners of a set, may be placed in position. They may be of greater length than the posts of sets above, the object being to afford more room overhead on the sill floor, if desirable. A temporary platform is constructed by spiking stout planks to the two sets of posts at right angles to the sills, and placing on them planks or lagging. This staging is built at a suitable height, to enable the men standing thereon to lift the heavy caps and place the ends upon the framed posts. The caps are placed directly above the sills; that is, in a direction extending from wall to wall.

Each post is framed with a tenon both top and bottom; that at the upper end being two thirds or three fourths, and that at the bottom, one third or one fourth the thickness of the cap. (See the detail draw

ings.) It is necessary that the bottom of each post shall rest directly upon the top of that in the set next below. All the timbers must be carefully framed or it will be found that they will not join properly.

Having placed caps upon the posts, the ties may also be lifted into position, crossing from post to post and resting upon them in the same manner as the caps, but at right angles to them. Ordinarily caps are broader on one side than on the other. The broad side is laid upward, the width of which is equal to that of the post, which is square. The tie is equal to the smaller width of the cap. The ties should fit tightly, and if they do not, must be secured by wedging at the ends. The best results are obtained when it is necessary to drive the ties down with mauls.

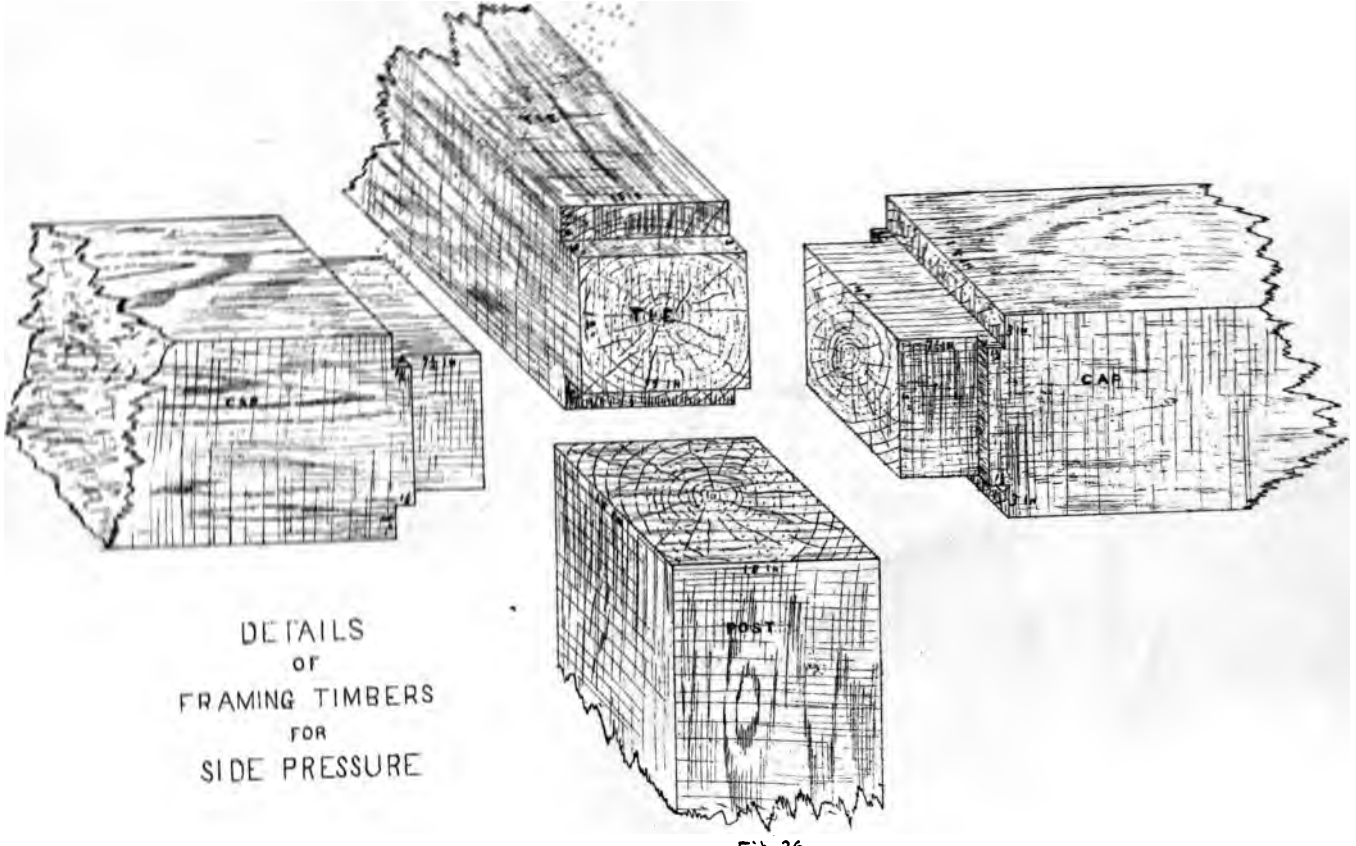
As the work of extracting the ore proceeds the timbering keeps pace with it. As the stopes are carried upward, set is built upon set, reaching from one level to another. Temporary working floors are laid, split lagging being used for this purpose. These floors are moved from time to time as the work progresses. Ore broken down on these floors is shoveled into the bins beneath, or onto the sill floor before the bins have been provided, and from there shoveled or dumped into cars and sent to the surface.

When timbers have been placed the wedges along the walls should be driven up between the plates and walls, and in all other places where needed, to secure firmness and rigidity, and some one man should be detailed to look after them and see that they remain so; for in large stopes the ground is constantly shifting more or less, and the weight being transferred from one point to another causes the wedges to loosen, when they must be again tightened to insure safety.

The size of timbers used in the square set system ranges from 8x8 or 8x10 inches to 20x24 or even 24x28 inches, though timbers of the latter dimensions are often difficult to obtain. When such massive timbers cannot be had, the sets may be constructed on a smaller scale, having a lesser distance between posts, and also less height to the set; thus greater strength is secured by the employment of a larger number of timbers.

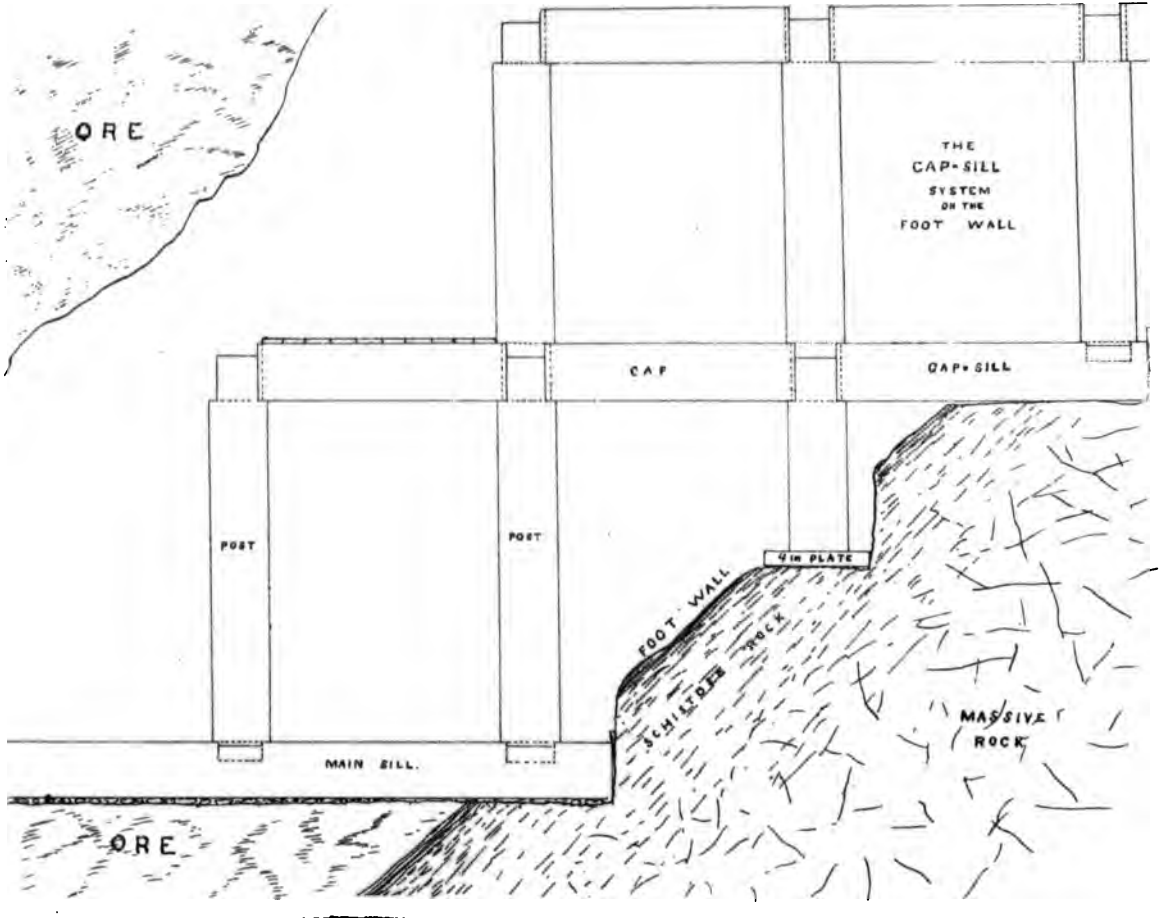
Caps encroach upon the posts 2 to 6 inches according to their dimensions, while ties have a rest of 1 to 4 inches, this being also determined by the size of the timbers. The posts are framed in accordance with the dimensions determined upon, which must be constant, to secure uniformity, whether the post be 16x16 or 24x24. As all caps are of the same length and all ties of an equal length, it is evident that if the tenons on the posts vary with any difference in the size of the posts (should any difference occur), the system would soon be out of line. As the timbers used are all sawed, it should not be difficult to secure them having a uniform size for any single stope. In any event, the tenons at the top and bottom of the post must have a uniform size regardless of the dimensions of the post. For instance, should 18-inch posts be in use on any particular level, framed with 12-inch tenons, if from necessity or choice a 20-inch or 24-inch post be introduced in the sets, it must have a 12-inch tenon, corresponding with the others. Square timbers are usually framed with gang saws, and are therefore uniform, and any particular stick, whether post, cap, or tie, may be used in any portion of the mine.

Posts and caps which come in contact with the wall plate are mostly framed by hand, to order, careful measurement having first been made to determine the exact dimensions. Caps which meet the plate within



DETAILS
OF
FRAMING TIMBERS
FOR
SIDE PRESSURE

Fig. 36.


ORE
THE
CAP-SILL
SYSTEM
ON THE
FOOT WALL
CAP
CAP-SILL
POST
POST
4in PLATE
FOOT WALL
SCHISTOSE
ROCK
MASSIVE
ROCK
MAIN SILL.
ORE

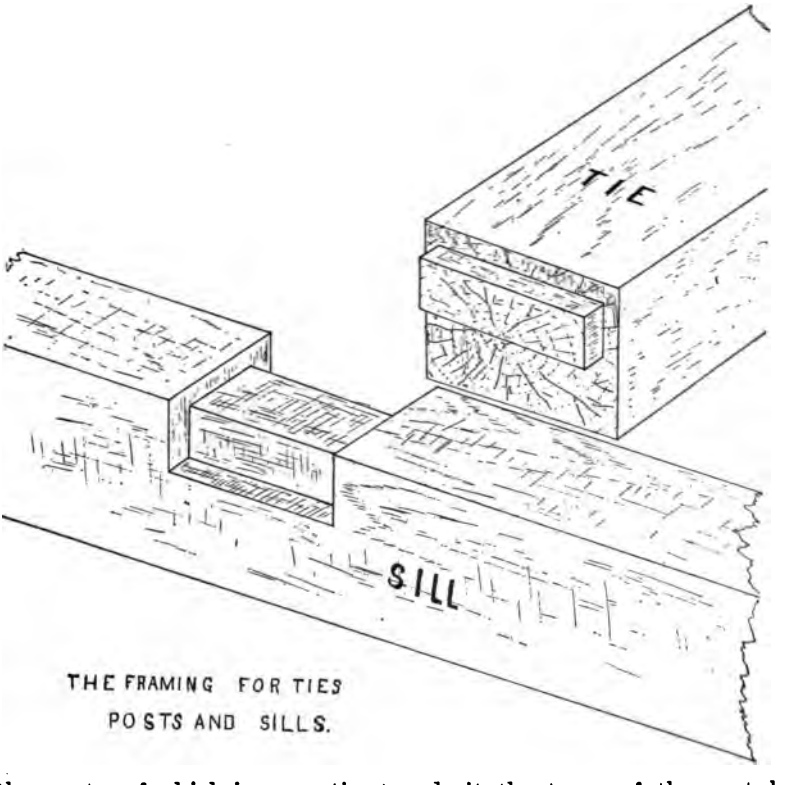
less than two thirds the width of the set are frequently made continuous from the second post. Wall plates are cut in sections, the length of which is determined by the conditions in the mine. These are also mostly framed by hand. The manner of framing and fitting these timbers will be understood by reference to the drawings.

CAP SILLS AND THEIR USE.

Cap sills are often used in preference to wall plates on the foot wall of a vein. They are applicable to small stopes as well as great chambers. As the name implies, these timbers are simply an extension of the cap from the post nearest the foot wall to the wall where it rests upon a hitch cut in the wall (2 feet or more, according to the character of the ground). It then forms a sill for the post of the set next above, as illustrated in the accompanying drawing.

AN IMPROVED SEAT FOR THE POST ON THE SILL.

The method commonly in use for cutting a seat for a post in the sill: that of cutting a section an inch deep entirely across the face of the sill,



THE FRAMING FOR TIES POSTS AND SILLS.

in the center of which is a mortise to admit the tenon of the post, has been superseded in some mines by a new practice, which has many advantages, particularly the ease with which all rock and other foreign

substance may be removed when ready to set the post. The tie or girt is let in on each side, they being cut out to the depth of one inch at the ends. The drawing will explain the idea better than a description. The posts have a tenon one inch only in depth. A longer tenon would afford no additional security or firmness.

RECOVERING LOST GROUND.

A great deal of good ore is sometimes lost by the settling of large veins upon the timbers of the first few floors of a stope so heavily as to throw the timbers out of line, when bulkheading and filling in must at once be resorted to, to prevent caving. In the Anaconda Mine, of Butte City, Montana, a case of this kind occurred. The timbers on the sill floor were forced out of line, and it was evident that a disastrous cave was imminent. The stope was packed full of timber and waste as rapidly as possible and the level abandoned. A drift was then run from a cross-cut in the foot wall, 60 feet from the vein, and in this lateral drift at distances of 60 feet, and directly opposite the chutes in the abandoned stope, as established by the mine surveyor, a square set was placed. A raise was then carried up on an incline to the vein, where it was still intact above the filled stope from each of these points. These raises were timbered with square sets, which in section would present the appearance of a series of steps. The rock in which the drift was run was solid granite, but as the foot wall was approached it was much decomposed and required substantial timbering. Had the foot wall country rock been firm and hard no timber would have been necessary, except at the stand on the floor of the drift where the loading chute was constructed and at the junction of the winze and foot wall of the vein. Through the winzes thus made the lost ore was almost entirely recovered.

DIAGONAL BRACES.

These timbers are necessary in heavy ground. It must be borne in mind that they, in a measure, perform the office of stulls, and should not be placed at right angles to the hanging wall, but at a higher angle. For instance, supposing the inclination of the hanging wall to be 45 degrees, the diagonal braces should stand at 55 degrees. The height and width of the sets must be determined by the desired inclination to be given the diagonal or angle braces, and before this can be determined the inclination of the hanging wall must be known. The angle braces may be of the same size as the posts or a little smaller. These timbers are not mortised nor framed with tenons, but are slipped in sideways and secured by thin wedges if they are not tight when put in place.

SIDE PRESSURE.

When the pressure is greater, apparently, from the side than from overhead, the method of framing and joining these timbers is somewhat different. The cap becomes the post. An examination of the drawings will convey an idea of the system employed under these conditions. The tenons at each end of the cap in this case are exactly the same size, *while the tie is* also provided with a tenon, but of different style from *that used where* the timbers are framed to resist top pressure. The

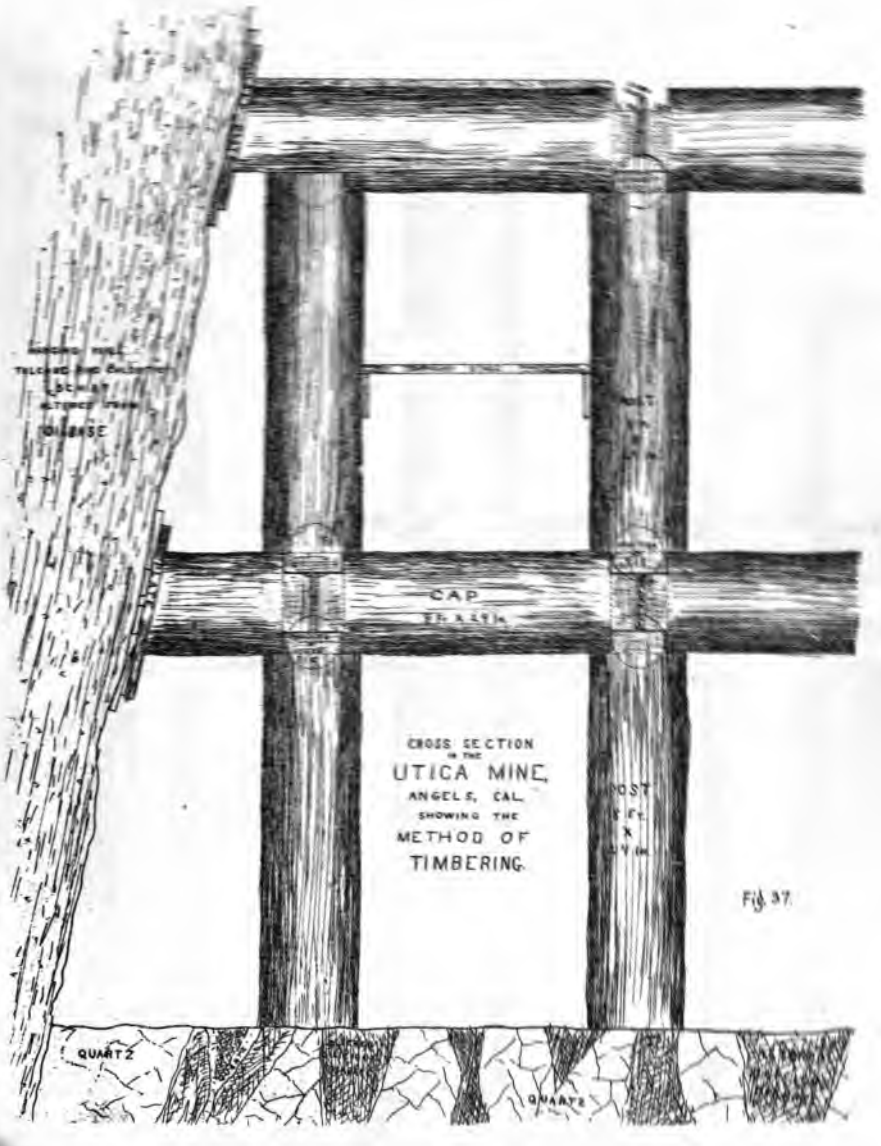

CAP
CROSS SECTION
IN THE
UTICA MINE,
ANGELS, CAL.
SHOWING THE
METHOD OF
TIMBERING.
QUARTZ
QUARTZ

Fig. 37.

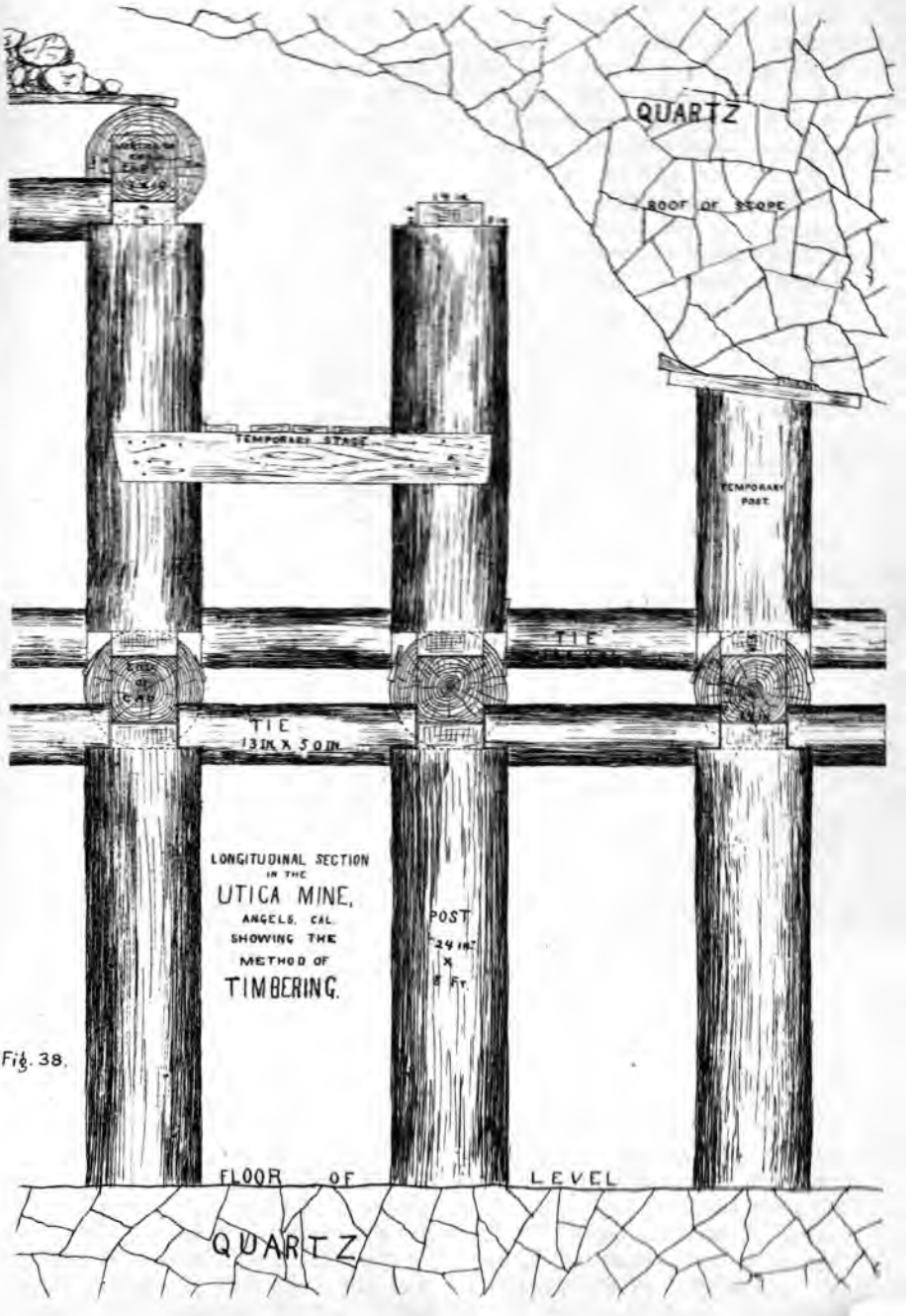
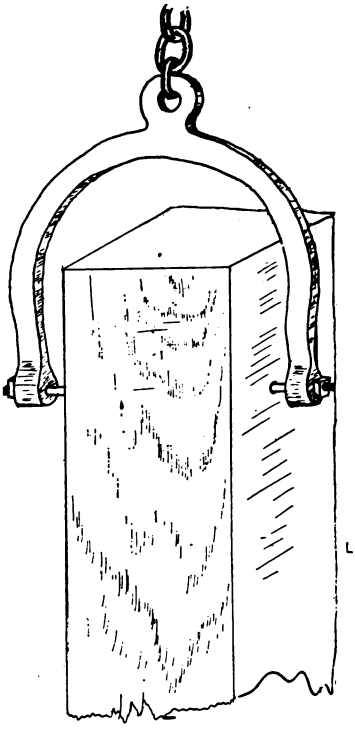

QUARTZ
ROOF OF STOPE
TEMPORARY STAGE
TEMPORARY POST
TIE
TIE
13 IN. X 5 0 IN.
LONGITUDINAL SECTION
IN THE
UTICA MINE,
ANGELS, CAL.
SHOWING THE
METHOD OF
TIMBERING.
POST
24 IN.
X
FT.
FLOOR OF LEVEL
QUARTZ

Fig. 38.

provided. In the center of each chain is a 4-inch ring, and at each end a dog, having a point projecting at about 70 degrees 4 inches in length. One of these dogs is driven into the side of a post or cap somewhat above the center. The chain is passed over the end of the timber and the other dog is driven into the opposite side. A spike 6 or 8 inches long, having a 5-foot piece of rope attached, is driven well into the lower end of the timber, and it is ready to lower into the mine. Beneath the skips are stout chains with rings. An extra chain having hooks at the ends is at hand. This forms the connecting link between the chain beneath the skip and that attached to the timber. Having been securely hooked the skip is raised slowly, lifting the timber from the platform. The rope and spike at the bottom are used to bring the timber to a standstill before the skip is lowered. Having reached the level where it is wanted the rope again comes into use in landing the timber at the station.



CLEVICE FOR LOWERING TIMBER UNDER THE CAGE OR SKIP.

The Utica shaft is almost vertical. This process, while a convenient and quick way of handling these heavy timbers, cannot well be used in shafts departing very far from the perpendicular, unless a slide of plank be laid between the guides or runway of the skip, and it would then be advisable to line the slides with strips of flat iron. It would appear that timbers might be handled in this manner in shafts having as low an inclination as 35 degrees, particularly if the slide be lubricated. It is certainly a superior method to that of loading the timbers into skips,

which involves much difficulty, particularly in landing them at stations. Most mines have blocks and tackle at the stations, secured to heavy timbers overhead, for unloading timbers from skips.

It is always a good plan, where possible, to have complete connection from level to level by means of winzes in veins requiring very large timbers. The timbers may then be unloaded on the level above where they are to be used and lowered through the winze nearest the stope where they are to be placed, and to the particular floor of the stope where they are required. Winzes for this purpose should have, if possible, an inclination of 65 degrees. Where the slope is too low for them to run, however, the timbers may be dragged down, which is certainly much cheaper and easier than hauling them up.

All timbers should be framed on the surface where possible, as it saves much time and trouble. Gang saws are much to be preferred to any other method of framing timbers for square sets. The timbers can, in this way, be framed as exactly if not more so than by hand, and in one tenth of the time.

In mines where cages are used, when it is necessary to send long timbers down into the mine, as sills for square sets, or long plates, much time is saved by boring an auger hole through the timber near the end and passing an iron bar ($\frac{3}{4}$-inch) through it. The ends of the bar are provided with threads and nuts. These ends pass through the ends of a U-shaped frame, forming a large clevis. The clevis is attached by a chain to the bottom of the cage, and in this manner lowered to the point desired. The principle is the same as that employed at the Utica Mine. The drawing on page 53 will convey an idea of the device above described.

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